A CONCEPTUAL APPROACH TO SOME LAND USE PROBLEMS IN KAJIADO DISTRICT

by

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Declaration

I, Margaret Hampson, hereby declare that the work contained in this Thesis is my own and has never been submitted for a degree in any other University.

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We, Professor Dr. A. Weber and Mr. P.B. Thresher, M.A., hereby declare that this thesis has been submitted for examination with our approval as University Supervisors.

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Nairobi
30 May, 1975

CONTENTS

CONTENTS

CONTENTS

SUMMARY

This thesis pertains to a particular area of Kenya, namely Kajiado District. Economically, this area has considerable significance as a livestock rearing area and for wildlife viewing and hunting. There is also some agriculture around Loitokitok in the foothills of Kilimanjaro. The majority of the area is plains and bush which is concurrently utilised by domestic and wild stock apart from the national parks from which livestock is excluded. The importance of this area is reflected in the fact that considerable development of both the wildlife and livestock sectors is being carried out. The livestock sector is being expanded and intensified under the World Bank Livestock Development Plan, while wildlife utilisation activities are being reorganised and increased by the UNDP/FAO Wildlife Management Project.

In order to allow this thesis to delve to meaningful depths the scope of this study has been restricted to the plains area of Kajiado District where the main potential forms of land use are by livestock and/or game. Since the major emphasis in the World Bank Livestock Development Plan is on cattle production this thesis has been limited to a consideration of the cattle industry only, though currently there are substantial numbers of sheep and goats which play an important role in the Maasai subsistence economy. On the wildlife side, discussion is limited to those forms of utilisation which are under review by the Wildlife Management Project, namely, tourism, hunting, cropping and live capture.

Some forms of wildlife utilisation are dependent on the rate of offtake, namely hunting, cropping and capture, while tourism is not. As discussed in the relevent section, tourism is the most valuable form of wildlife utilisation but it receives less emphasis in this thesis than the former types of utilisation. The reason for this is that one objective of this thesis is, using a conceptual approach, to develop offtake

rate formulae for the wildlife and cattle sectors. However, the application of these formulae are subjective since the data required to determine the offtake rates will vary between areas and species and in many cases the data may not be available. On the basis of the cattle offtake rate formula, potential revenue formulae have been developed. As far as the wildlife sector is concerned there is insufficient data on the demand situation within the hunting, cropping and capture activities to usefully develop potential revenue formulae. However, since the overall concern of this thesis is with land use optimisation the existing values of these forms of utilisation have been examined, and, in order to provide a true picture the value of tourism is also discussed.

The second objective of this thesis is to determine the problems of defining and implementing an optimum land use pattern, which includes the utilisation of a renewable natural resource, in Kajiado District.

In order to fulfil these objectives the thesis has been set out as follows:-

Chapter I is a description of Kajiado District so that a full background is provided. Statistics are included to give a fuller understanding but are not used later on because of the conceptual approach which has been adopted.

Chapter II is concerned with the conceptual development of offtake rate and potential revenue formulae for the cattle industry.

Chapter III is devoted to a discussion of wildlife utilisation activities. Firstly, offtake rate formulae are developed using a conceptual approach and secondly the value of each form of wildlife utilisation is examined.

Chapter IV outlines the principles of land planning and discusses the way in which these apply to Kajiado District. It

is also concerned with the way in which land planning techniques to determine the optimum intensity and distribution of cattle and wildlife utilisation activities might be applied to this area.

Chapter V is the concluding chapter and discusses the problems facing land planners and outlines the most pressing questions which need to be answered.

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CHAPTER I

KAJIADO DISTRICT -

A SITUATION REPORT

INTRODUCTION

This first Chapter is concerned with a discussion of the current situation in Kajiado District and the developments being carried out there with respect to the livestock and wildlife sectors. There are three sections.

Section I provides background information about this area covering the main features of location, political and physical features, vegetation, climate, communications and inhabitants.

Section II considers livestock. For the reasons outlined in the introduction this discussion is limited to the cattle industry and looks at the traditional situation and developments under the World Bank Plan.

Section III deals with wildlife, covering current and potential forms of utilisation and some of the associated problems. The role of the UNDP/FAO Wildlife Management Project is also defined.

SECTION I

MAIN FEATURES OF KAJIADO DISTRICT

A LOCATION

Kajiado District is situated between 36° and 38°E and 1° and 3°90'S. It lies to the south of the Nairobi-Mombasa railway, being bordered by the Nguruman Escarpment in the west, Tsavo West National Park in the East and the Kenya/Tanzania border to the south. In area it covers some 8,000 square miles.

B POLITICAL FEATURES

Kajiado District is divided into several areas for administrative purposes as shown on Map I[I].

C PHYSICAL FEATURES

The main physical features of Kajiado District are shown on Map I[II]. It is principly a plains area with the Aguruman Escarpment and Suswa in the west, the Ngong Hills to the north, the Chyulu Hills in the northeast and Kilimanjaro in the south. These plains are drained by five permanent rivers namely the Ewaso Ngiro in the west, the Namanga in the south, the Athi and Selengai in the north and the Magoine and Lolterish in the east. During the rainy seasen there are also numerous seasonal rivers. In addition springs and streams drain from Mount Kilimanjaro. The major swamps are the Ngare Swamp in the west and the Loyinye, Kamalog and Kimana Swamps to the east. Kajiado District has two main lakes, Lake Magadi, a soda lake, and Lake Amboseli which is in the process of drying out.

D VEGETATION

The Wildlife Management Project has recently completed a survey of the vegetation which has been defined as follows.

Kajiado District has been divided into ecological zones based on criteria of Trapnell and Griffiths (1960), Pratt, Greenway and Gwynne (1966) and Survey of Kenya (1971) as shown in Map I[III]. As adequate long-term climatic data are lacking, zone boundaries at least in part have been dictated by distribution of key indicator plants and by topography and soils.

Ecological Zone V

Ecological Zone V is the largest, comprising 65.6% of the District. Basically, it includes the low-elevation Rift Valley, the Amboseli Basin as far west as Namanga, and the dry *Acacia mellifera* - *Commiphora africana* bushland of the Kiboko drainage below 1500 m. Because of the low rainfall and high temperature, forage production of both grasses and palatable shrubs is low.

Ecological Zone IV

Ecological Zone IV covers 31.6% of the District. This Zone contains more productive grassland, bushed or wooded grasslands, and bushland than Zone V. It usually occupies ground above 1500 m, or areas with better soil moisture, as near the Nguruman Escarpment. The central and southern Athi Plains, the grasslands of the Emali-Selengai area, and the productive bushed grasslands from Kajiado to Namanga are included. Characteristic trees and shrubs are Acacia drepanolobium, A. tortilis and Croton dichogamos. Themeda triandra, Cynodon spp., Pennesetum mezianum and Cenchrus ciliaris characterize the better sites; Eragrostis spp., Sporobolus spp., Microchloa kunthii and Harpechne schimperi may occupy poorer sites or disturbed areas. Except in drought years or on overused ranges, forage production is high.

Ecological Zone III

The highly productive Ecological Zone III covers only 288 km^2. The most productive northern Athi Plains, bordering Nairobi National Park, are included, as is a rocky ridge area of thin soils northwest of Kajiado. Forage production is high, composed mainly of Themeda triandra, Pennesetum spp., Hyparrhenia spp., and Digitaria macroblephara. When subjected to abuse, recovery is more rapid than the drier Zones IV and V. The agricultural area (generally on the most productive soils) between Kiserian and Ngong, falls in this Zone, overlapping slightly into Ecological Zone II.

Ecological Zone II

Ecological Zone II occurs only on the summits of the highest mountains - Ngong Hills, Chyulu Hills, and Ol Doinyo Orok. Productive, well-drained soils and high rainfall make this land of the highest potential, although steep slopes and

exposed rock render much of it generally unsuitable for agriculture. Its value as watershed is high. The area is presently covered with forest, with interspersed highly productive grassy glades. Characteristic grasses are Hyparrhenia spp., Cymbopogon spp., and Themeda triandra.

Ecological Zones I and VI are not found in Kajiado District.

E CLIMATE

Information about the climate is somewhat general due to the small number of meteorological stations in this area, namely Athi River, Magadi, Kajiado and Kiu.

a. Rainfall This aspect is of considerable interest because it has a direct effect on cattle and wildlife numbers as will be discussed later on.

There are two rainfall regimes: two rainy seasons and the single rainy season. The former occurs in Kapatei district with 50% of the total annual rainfall during the period of March to May and 25% in November and December. The remainder of Kajiado District has a single rainfall season with 85% of the total annual rainfall between November and May. Generally, rain falls in convective storms of half an hour to three hours duration but on hill slopes and areas effected by highlands there are drizzles of long duration.

Map i^{IV} shows the mean annual rainfall. There is a rapid increase in rainfall of 20" per 1000' above 7000' on the Nguruman mountain range.

The Magadi-Natron area and Nyiri desert are rain-shadow areas. Griffiths and Gwynne (1962) estimate an annual rainfall of 10" per annum in the Nyiri desert. Detailed information about variability of monthly and annual rainfall for the areas in which

the meteorological stations are situated is available. However, it is of particular significance to note that as annual and monthly rainfall decreases so the degree of variability increases.

b. Temperature Using available data Griffiths and Gwynne (1962) developed the following equation for mean annual temperature (^{o}F) = 93.2 - 4.8 x altitude (thousands of feet).

A maximum temperature of over 105^{o}F is rare but temperatures of over 100^{o}F are likely to be recorded at less than 2500 feet.

Mean monthly temperatures lie within ± 3^{o}F of the mean annual temperature with February the hottest month and July the coldest. However, individual days can vary ± 10^{o}F from daily average temperature and the mean diurnal temperature range is between 20^{o}F and 30^{o}F.

c. Humidity Dew point (temperature at which dew is formed when the air is cooled) shows little variation (± 2^{o}F) during the day and is steady from month to month (± 3^{o}F of annual mean).

F COMMUNICATIONS

Generally speaking communications systems within Kajiado are poorly developed (see Map I^{II}). The Nairobi-Mombasa railway runs along the northern boundary between Athi River and Kiboko and has branch lines to Magadi and Kibini. The road network is very poor, the only tarmac road in this district being the Athi River - Namanga road, although the Nairobi - Mombasa road lies just to the north. All other roads are either murram or dirt and it can be seen from the map that some areas are poorly served even by these minor roads.

INHABITANTS

As the 1969 population census does not give sufficiently detailed information it is not possible to give a detailed breakdown of the Kajiado District population. However, the vast majority of the population inhabiting the plains area are Maasai but again lack of data prevents an accurate estimate of their numbers. However, the Veterinary department* estimates that in 1969 the human population was approximately 86,000 and that prior to the 1974 drought the cattle population was approximately 700,000. (see Appendix I[I] for discussion about the relationship between the Maasai and cattle population levels). Traditionally the Maasai are not only dependent on their cattle for subsistence survival but also as an indication of social status. Thus, it is in the interests of each individual to own as many cattle as possible. In addition, considerable herds of sheep and goats are kept. Again there are large discrepancies in the estimates of the numbers of sheep and goats. Prior to the 1974 drought Mr. G. Murphy of the Agricultural Finance Corporation estimates there were one million while Mr. H. Watson's aerial surveys suggest half this figure. Dr. D. Western estimates that sheep and goat numbers are 65-70% of the cattle numbers.

There is a discrepancy of opinion as to the minimum size of herd required to support a family at milk subsistence level. For example, the Agricultural Finance Corporation bases its planning on the assumption that a six person family requires a herd of twenty head of breeding female cattle. The Veterinary department* estimates cows comprise 57% of the herd, which suggests a herd of forty two animals. On the other hand Mr. R.M.H. Lewis (1967) indicates that from observations a herd of sixty to seventy head is necessary to provide subsistence requirements plus a cash income for basic requirements. This

* Ministry of Agriculture.

discrepancy is probably due to difference in definition of subsistence, the former discounting the element for cash income because under the Agricultural Finance Corporation ranch development schemes, cash income is derived from commercial beef production activities. A second reason for this discrepancy is that the size of the subsistence herd needed to support a family will depend on the severity of the dry season. Hence, it is desirable to introduce a third statistic in the form of the time period for which a subsistence herd is expected to support the family.

SECTION II

LIVESTOCK

A TRADITIONAL SITUATION

a. Traditional Livestock Management

As noted earlier the natural water supply in much of Kajiado District is seasonal and as a result the Maasai have adopted a semi-nomadic way of life in order to utilise the best and much of the range as possible, and thus, maximise the number of livestock owned. In the dry season they occupy land where permanent water is available and in the wet season they move out to areas supplied only by seasonal water. This movement is especially noticeable for cattle since they are less drought resistant than goats and sheep. The concept of overstocking is a foreign idea to the Maasai since in this semi-nomadic condition with common utilisation of land it is always advantageous for the individual to increase his stock. The Maasai's tolerant attitude in the past towards wildlife has been a result of their inability to effectively wipe it out. Also the semi-nomadic way of life results in any competition between wildlife and livestock not being as

apparent as under a developed ranching set up. The Maasai have a particular dislike of wildebeest, though, since malignant catarrh, a fatal disease is endemic in their populations. However, as discussed further on statistics show an insignificant number die from this disease. During the season when wildebeest are most likely to infect cattle with this disease (namely from calving till the young wildebeest sheds its first coat) the Maasai avoid grazing their cattle near wildebeest herds.

b. Factors Controlling Herd Size

(1) Herd Structure

The structure of the herd is directly influenced by the fact that the Maasai mainly utilises his cattle for milk and blood and not meat production. Usually beef is only consumed on special occasions or when an animal dies through natural causes or is slaughtered because of infertility. Estimates of herd structure by A. Jacobs (1967) and the Veterinary Department of the Ministry of Agriculture give a ratio of 57% cows, 6% bulls, 11% steers and 26% calves. This high proportion of cows is not only important for milk production but facilitates a rapid build up of cattle numbers in favourable conditions. Taking a calving index of eighteen months this results in the number of calves born each year being equal to 40% of the total population. Depending on prevailing conditions calf survival can vary between 20-80% which gives a potential herd increase of 8-32%. While an individual may consider this desirable, especially after a period of unfavourable conditions during which herd numbers have been reduced, it has a tendency to lead to general over-stocking and a cyclical movement of herd numbers. Thus,

heavy rains result in a good milk supply which leads to a high calf survival and hence a large number of immatures. The resulting shortage of grazing due to overstocking leads to stunting of growing cattle and death of weak animals.

(2) Rainfall

The amount of grazing and drinking water available is a direct result of the level of rainfall which in turn influences the birthrate, calf survival rate and death rate in adults. During the 1961 drought, breeding appeared to stop but the surviving cows got into calf quickly so that there was almost a 100% calving rate by November 1962. The quantity of milk available is influenced by the availability of grazing and water. Since the moreni (young men) and children get fed first and the calf has the remaining milk the effects of low milk production are magnified and calf mortality through malnutrition is likely to occur. In addition cold and unseasonal rain may lead to chilling and low disease resistance in undernourished calves. Low rainfall and the resulting lack of grazing also causes death in the adult population. Starvation mainly affects the young and old but if the drought is severe enough all age groups are affected.

(3) Disease

Tick borne diseases, especially East Coast Fever are the main causes of death in adults while calf scours, pneumonia, coccidiosis and other Endoparasites are very common in calves and account for a high mortality rate. Foot and Mouth disease is also widespread. East Coast Fever and Trypanosomiasis are especially prevalent when cattle are taken out of their normal grazing areas during

droughts. Infection and death is most likely when the animals are already weakened by starvation. The spread of disease is facilitated by the Maasai practice of boma-ing cattle at night to protect them from theft.

(4) Predation

Losses through predation by wildlife, based on available data appear to be negligible. For example, records show that over a period of two years (1971/2) in Loitokitok Division, twenty five cattle, thirty six goats and five donkeys were killed. However, records are often not accurately kept and in some areas not kept at all.

B LIVESTOCK DEVELOPMENT

a. Background

The Maasai are noted for their conservative attitude to change but one main reason is put forward as to why they are giving up their nomadic way of life and settling on ranches. The Maasai cattle population was drastically reduced in the 1961 drought and these losses were further increased by the subsequent floods. Prole (1967) estimates that the cattle population fell from 680,000 in 1960 to 200,000 in 1962. A similar situation has just occurred in the 1974 drought. In 1962 those Maasai living in Kaputei realised that while the neighbouring European ranches which had invested in water development were also suffering serious losses, these were nowhere near the magnitude of their own losses. This acted as an incentive to form ranches and undertake water development, and together with the fact that Kaputei is one of the more fertile and higher rainfall areas of Kajiado District explains why the first group ranches were developed there.

b. World Bank Livestock Development Plan

Kajiado District is one of the areas being developed under the World Bank Livestock Development Plan. Phase I of this plan commenced 1 May, 1969 and has been extended from mid-1973 to

to mid-1974 because the available funds had not been fully utilised. Consequently Phase II was postponed and commenced in mid-1974.

Finance

This project is being funded and executed in two phases. Phase I is being financed by the Swedish International Development Agency and the Kenyan Government with the overseas aid being channelled through the World Bank and in the region of twenty million shillings has been allocated to Kajiado District. In Phase II the United States of America and Great Britain are also contributing and the development funds for Kajiado District amount to approximately twenty three million shillings.

Organisation

The World Bank is working through the relevant Government departments. The Range Management Division is responsible for preparing ranch development plans in conjunction with the Water Development Department and Agricultural Finance Corporation, and following this up to the stage where a loan is filed with the Agricultural Finance Corporation. They also assist the Agricultural Finance Corporation with post loan supervision and provide management on group ranches. The range water section of the Water Department investigates and surveys water supplies and constructs and develops water supplies in line with development plans. The Agricultural Finance Corporation organises the provision of loans to carry out these development plans. Disease control aid is channelled through the Veterinary Services Department and is mainly concerned with Foot and Mouth Disease control and Contagious Bovine Pleural-pneumonia eradication. The Livestock Marketing Division of the Ministry of Agriculture is also receiving aid for disease control and the development of marketing systems.

c. Ranch Organisation

(1) The Current Situation

In Kajiado District two types of ranch are being developed under the Livestock Development Plan, namely group and individual ranches.

Group Ranches

The concept of group ranches was developed because in much of Kajiado, land potential is fairly low and water is relatively scarce dictating that in order to be viable, ranches must be large. On the other hand the population is too large to adjudicate a sufficient number of individual ranches. Thus the concept of a ranch occupied and jointly owned by a group of people arose. Control of these ranches by its members is democratic. On registration as a member of a group ranch an individual is given a stock quota. Cattle are still traditionally managed on these ranches and as a first step towards developing commercial cattle production, priority is being given to loans for the construction of dips and water development. Under Phase I such development is being carried out on nineteen group ranches and there are plans to develop another twenty five group ranches in Phase II. Phase I group ranches are all situated in Kaputei while Phase II group ranches are also situated around Ambeseli. Their average size is in the region of twenty thousand hectares and the average number of families on each ranch is one hundred and forty. However, there is considerable variation depending on the prevailing social and ecological situation. See Table I.

Individual Ranches

In the case of individual ranches the title deeds are in the name of a single person and average about six hundred hectares. Forty five individual ranches are being

developed and under Phase II it is planned to develop another forty five. These individual ranches are located in Kaputei and around the Loitokitok area. Not only is water development and dip construction being undertaken but also artificial insemination and improved breeds have been introduced. In this way individual ranches have a demonstration effect, in the sense that it is often easier to persuade an individual, rather than a group of people, to adopt a new idea. When members of group ranches see developments such as artificial insemination and dipping being implemented on individual ranches it is hoped that they will want to follow suit.

(2) Ranch development

Lending Policies

Ranch development in this area is being carried out with the aid of loans from the Agricultural Finance Corporation. There are two main types of loan: Steer purchase loans which are short term loans for buying steers and development loans for the long term development projects set out below. To be eligible for either type of loan, loanees must have at least 20% equity in the total ranch assets after full disbursement of the loan funds and an internal rate of return of 15% for the project is required. An interest rate of 7.5% is payable on the outstanding balance for all loans. The maximum duration of development loans is twelve years. These loans will carry up to a four year moratorium on principal repayments followed by equal annual principal instalments for the remaining duration of the loan. On the other hand all short term credit is assessed annually, but as with development loans working capital loans do not exceed twelve years.

Development Investments

The Agricultural Finance Corporation divide development items into the following investment categories: water facilities and equipment, livestock facilities and dips, constructions, machinery, firebreaks, fencing, bulls, cows and bush clearing.

Water development has gained priority because of the need to open up areas of the range hitherto inaccessible because of lack of water and thus make the newly adjudicated ranches viable. In this way the range can be utilised more efficiently and effectively. However, there is a basic fallacy in this argument which is put forward by those developing the livestock sector. The provision of watering points in previously dry areas will result in an increased number of cattle, not the original number of cattle having more grazing available for them. This, together with the fact that the provision of watering points will not influence primary vegetation production in drought periods means that the overstocking problem which Kajiado District already faces will be intensified. Investment in dips and sprayraces gained importance in an effort to control tick-borne diseases. In many areas it is necessary to dip twice weekly in order to control such diseases. To this end at least 50% of development funds have been allocated to water development.

Improved stock is the other major area of ranch development: investment in improved bulls accounts for 16% of the loans to group ranches and 10% of loans to individual ranches. Stock is being improved in two ways. Firstly, there is provision, under the Livestock Development Plan, for loans to buy improved breeding livestock. Secondly, subsidised artificial insemination has been introduced.

It is of importance that the quality of the Maasai herds should be improved. The human population in that area is increasing and in order to maintain it at milk subsistence level or higher, milk yield per cow must rise so fewer cows can support more people allowing more cattle to be used for beef production. This argument is realistic only if the improved cows introduced can produce more milk than a traditional animal given the same conditions. If, for example, an improved breeding animal could produce twice as much milk as a native animal but needed twice as much food to achieve this, then in practice, the situation has not been improved. Income from increased beef production is necessary to provide a cash income and money to repay development loans. Compared to the northern cattle raising areas, Kajiado is a good "finishing" area, and therefore, steer purchase loans feature as a major part of the development programme. In addition, the Kenya Meat Commission has a credit system whereby it buys up cattle and ships them to "finishing" areas such as Kaputei or Loitokitok. Credit is provided in the sense that ranchers do not pay for the cattle until they are sold for slaughter through the Kenya Meat Commission.

d. <u>Disease Control in the Livestock Sector</u>

Disease problems are considerable not only because they are responsible for reducing livestock numbers but also in that they limit the movement of livestock and limit potential markets because of their effect on quality. Interaction of disease between livestock and wildlife only occurs for some diseases and this aspect as discussed later.

<u>Rinderpest</u>

This used to be one of the main factors controlling cattle population but as a result of a rinderpest vaccination scheme introduced in 1942 it is now clear.

Contagious Bovine Pleural-pneumonia

As long ago as 1945 there was an attempt to innoculate the entire cattle population against contagious bovine pleural-pneumonia. This disease has now been controlled, through vaccination schemes which ceased in 1973. A serum survey was set up in 1974.

Foot and Mouth Disease

Currently there is a compulsory Foot and Mouth Disease campaign and it is to be taken over by the Swedish International Development Association in Phase II. In recent years Foot and Mouth Disease has been one of the main inhibitors of development, preventing cattle sales and the movement of cattle out of the area. However, it is hoped that this problem can be solved in conjunction with the vaccination campaign by introducing holding grounds into the marketing system. On arrival at the holding ground in a quarantine area, cattle are checked for Foot and Mouth Disease, held for a week and checked again. If disease-free they would be vaccinated, held for a further three weeks and shipped out of the area by lorry or train.

Tick-borne Diseases

These diseases can be controlled by frequent dipping. However, this implies that the movement of cattle is limited to a few days walk from the nearest dip.

Malignant Catarrh

This disease is carried by wildebeest and maybe also sheep, but the young and their mothers are only able to spread infection during the first few months of the calves life. As yet no cure is known. However, its incidence in cattle appears to be low: The Veterinary Department estimates there

were around six hundred cases out of the one thousand reported in the four year period 1970/73, although it is probable that not all cases are reported.

Tapeworm

'Measles', Cysticercosis bovis, is spread by the human population. It is, however, of considerable economic importance because of the heavy price penalty imposed by the Kenya Meat Commission when carcasses are found with this parasite. It should be pointed out that while tapeworm cysts are found in wild animals they are not the variety to which humans are subject. This has been shown by work carried out by the Wildlife Management Project, and game meat lightly infected by tapeworm cysts is released unconditionally for human consumption.

Blackquarter

This disease appears to be endemic and vaccinations are carried out on request and upon payment by the livestock owners.

Anthrax

The incidence of anthrax is low. For example there was one confirmed case in 1973 and three in 1972. On the other hand approximately eighty human cases were reported each year in the period 1971/73. A blackquarter/anthrax combined vaccine is always used in Kajiado District.

Trypanosomiasis

This disease is widespread and there is a vaccination campaign in operation.

Brucellosis

The Veterinary Department estimates that 10% of the cattle in this area are infected at one time or another. Control of this disease appears to receive little attention.

Calf Diseases

Calf scours, pneumonia, coccidiosis and endoparasites are common and reflect poor management.

Endoparasites

These are common and combatted by drenching.

e. Marketing Systems

(1) Kenya Meat Commission has the "sole and exclusive rights" to purchase and process slaughter stock. The main Kenya Meat Commission slaughterhouse serving Kajiado is at Athi River. In addition, there is a small abattoir at Ngong which has recently been taken over by the Kenya Meat Commission. (Detailed figures on throughput and grading should be available from the Kenya Meat Commission.

Kenya Meat Commission Beef Producer Prices (per kg CDM)

Grade	Jan 1969	Feb 1972	May 1973	Jan 1974	1975 (projected prices under Phase II)
Prime	3.37	4.70	4.70	5.35	6.00
Choice	3.09	4.45	4.69	5.30	5.70
FAQ	2.87	4.20	4.41	5.00	5.50
Standard	2.54	3.15	3.42	4.20	4.50
Commercial	2.30	2.80	2.94	3.70	4.00

(The majority of beef produced in Kajiado District is expected to be of Standard quality or lower)

Sales to Kenya Meat Commission were 21,207, 19,867 and 22,019 in 1971, 1972 and 1973 respectively.

Extra Kenya Meat Commission Organised Market

County Council Sales

County Councils hold auction sales where slaughter and immature stock is bought by traders, butchers and the Livestock Marketing Division. Most of these cattle plus stock sold by private arrangement are killed in slaughter-

houses on slaughter slabs or in the open. Municipal and County Councils licence slaughter premises and so exercise health control measures. However, there are no municipal authority premises at Kajiado. Estimates of the numbers of animals slaughtered vary greatly as the following figures relating to Ol Kejuado in 1964 indicate.

Livestock Slaughter Estimates for Ol Kejuado (1964)

	Cattle	Sheep	Goats
Number of animals slaughtered			
Veterinary Department Survey*	4,224	2,125	shoats
Aldington and Wilson Institute for Development Studies Report (1968)	7,549		3,781
Slaughterings on unlicenced premises			
Veterinary Department Survey*	1,128		180
Institute for Development Studies Report (1968)	4,200	168	2,500

Dalgetti Auctions Limited

This organisation is licenced by the Kenya Meat Commission to auction a limited number of cattle at semi-permanent auction sites in the Rift Valley. During the period 1961/68 they held several auctions at Konza.

Dagoretti Abattoir

This abattoir handles about four thousand cattle per month. They pay cash and offer 30-50 cents/kilo above Kenya Meat Commission prices. This is possible because they do not have a penalty for 'measles' and their overheads per animal are about 25% of Kenya Meat Commission costs.

* Ministry of Agriculture.

Total Extra Kenya Meat Commission Cattle Sales

The Veterinary Department gives the following estimates of cattle sales in Kajiado District other than sales to Kenya Meat Commission.

Total Cattle Sales in Kajiado District

	1971	1972	1973
Slaughtered locally	N/A	3,549	24,519
to other districts for slaughter	11,706	5,189	7,113
to other districts not for slaughter	NIL	NIL	377
Exported to Tanzania	N/A	205	1,631

(2) Developments under Livestock Development Plan

Holding Grounds

Under Phase I a series of holding grounds, averaging two thousand acres, have been developed at twenty mile intervals by the Livestock Marketing Division.

Livestock Purchasing Centres

It is proposed to develop livestock purchasing centres at Kajiado, Mile 46, Kitengela, Bisil, Namanga, Kuku, Mashuru and Ewuli under Phase II. Each purchasing station would be developed on a holding ground and would be equipped with watering facilities, sales yard, weigh-bridge, housing and offices where these facilities do not already exist. Regular sales would be held on these sites subject to disease restrictions. In areas subject to Foot and Mouth disease quarantine it would be possible to move out two hundred head per month per centre under the system described in the disease control section. Centres not under quarantine could hold larger sales more frequently. These centres would be self financing through marketing fees levied.

Livestock Transport Programme

Also under Phase II it is planned to introduce cattle trucks to improve the poor transport situation. This transport will also assist in overcoming the Foot and Mouth disease problem since animals from holding grounds which have been declared free of the disease can be moved out of, or through, infected areas without risk of contamination. Rates are projected at fourteen cents per head per mile. It is anticipated that such cattle transport will be taken over by private businesses within nine years at rates equal to or less than Livestock Marketing Division rates. Also, stock routes are being developed.

In addition, the railway is a well utilised form of stock transport. On the Mombasa line there are loading points at Athi River, Konza, Sultan Hamud and Simba. On the Magadi line there is a loading point at Kajiado and one planned at Mile 46.

SECTION III

WILDLIFE

Kajiado District is one of the main areas in Kenya which supports the remnants of a once abundant and varied wildlife population in addition to its livestock population. The main species and their numbers and distribution are given in Tables I^{II} and I^{III}.

A The Advantages and Disadvantages of Maintaining Combined Livestock/Wildlife Populations

The game population competes with, but to some extent is complementary to, the domestic stock population. The disadvantages of wildlife and livestock inhabiting the same areas are as follows. Firstly, the presence of wild animals makes, to some extent, disease control more difficult and expensive

because not only are there a variety of diseases endemic amongst them (particularly malignant catarrh in wildebeest and foot and mouth disease) but also, they carry ticks which assist the spread of diseases, particularly East Coast Fever. However, even if wildlife was eliminated, dipping would still be necessary to control ticks. Foot and mouth disease is of major significance because an outbreak of this disease amongst the cattle population results in local quarantine to try and prevent its spread. This obviously has a very disruptive effect on the organisation of cattle marketing. Again, even if there were no wildlife, an extensive control operation would still be necessary to keep the disease in check. Malignant catarrh is particularly serious because it is a fatal disease for which there is no known cure. The Maasai have a particular dislike of wildebeest because this disease is endemic in their populations, but if one considers the mortality rates from this disease given previously, they would appear to have little grounds for complaint. Secondly, they compete with livestock for water, and, depending on the species, also for food. Thirdly, larger species are liable to damage fences and other constructions.

On the other hand, the presence of game can have advantages for the livestock sector. For example, certain species of herbivore such as giraffe and gerenuk assist in the control of bush encroachment. Also, small and medium sized herbivores provide a buffer against predation losses in areas where the large predators are present.

In many cases game can conserve and utilise the range more efficiently, in biological terms, than livestock, particularly cattle. Whether game is more efficient in economic terms is the underlying question of this thesis. Game has this ability to efficiently utilise the range because different species feed on

different parts of the same plant providing a more even pressure on the plant habitat than if it was grazed by just one or two species. In this way the range is able to support a greater biomass (sum total of the weight of all animals in a given area) without showing the deterioration expected if only one or two species were present. One of the main objectives of this thesis is to develop offtake rate formulae. Then, once the data is available it is possible to determine physical offtake rates which can then be converted into potential economic return from each offtake rate dependant form of utilisation. Secondly, many species (e.g. giraffe and oryx) are adapted to a low drinking water intake so that not only can the dry areas which are inaccessible to cattle, be utilised, but also grazing pressure around waterholes is reduced.

B Wildlife Utilisation Activities

a. Potential Forms of Wildlife Utilisation

There are six major ways in which wildlife can be utilised:-

1. Tourist Viewing - Tourists, both residents and non-residents, pay fees to enter National Parks and view the wildlife there. However, entrance fees to national parks are nominal and represent an insignificant proportion of tourist expenditure. Wildlife is also directly responsible for the revenue earned by lodges and bandas situated in or near these parks and the tour operators which provide transport to, and in national parks. Overseas tourists are of particular significance because they are a source of foreign exchange.

2. Trophy Hunting - Hunted animals earn revenue in the form of licences and fees payable to the Game Department and landowners. In addition, hunters purchase the relevant goods and services associated with the hunting activity.

A feature of this industry is that it makes a minimal demand on infrastructure, and yet is a significant source of foreign revenue. It should be emphasised that illegal hunting can account for a significant offtake particularly for species such as zebra and elephant.

3. Capture of Live Animals - The main demand for live animals is from zoos and wildlife parks outside Kenya and is therefore a source of foreign exchange.

4. Cropping for Livestock Products - Game animals can be cropped on the range and main products of meat and hides marketed locally or exported.

5. Game Ranching - Specific species which are easily handled and produce good quality meat (e.g. eland) may be ranched by keeping a controlled population of the required species in paddocks at the expense of maintaining other species.

6. Subsistence Hunting - by indigenous peoples.

b. The Current Status of Wildlife Utilisation Activities

1. Tourist Viewing - Two national parks exist in Kajiado District; Nairobi National Park (44 square miles) and Amboseli National Park (30 square miles stock free area). Neither of these parks are complete ecosystems and so their wildlife population is also dependent on surrounding areas. In economic terms this is the most important form of utilisation and the full significance of this industry is discussed later. It is necessary that the tourist industry in this area is planned so that the maximum national benefit is derived and then ensure that the landowners around the parks who support the parks' populations during the wet season receive sufficient transfer payments to induce them to continue to do so.

2. Trophy Hunting - Kajiado District is one of the main hunting areas of Kenya. Hunting constitutes the second most economically important form of utilisation and is analysed further on. From January 1974 the hunting industry in Kajiado District only has been reorganised. See Appendix I[II].

3. Capture of Live Animals for Sale - Live capture is only carried out on a small scale compared to the offtake by hunters.

4. Cropping for Livestock Products (Meat and Hides). The UNDP/FAO Wildlife Management Project has been experimenting with cropping and an analysis of potential costs and revenues has been made in this thesis. However, work to date suggests that total revenue from cropping is overshadowed by tourist revenue and revenue per animal viewed or hunted is significantly greater than revenue per animal cropped.

5. Game Ranching - Currently there is no commercial game ranching in Kajiado District.

6. Subsistence Hunting - The Maasai are not now dependent on game for subsistence hunting requirements.

C The UNDP/FAO Wildlife Management Project

The Government of Kenya has pledged itself to maintain wildlife in Kenya in spite of the growing pressures from other forms of land use and the problems involved in trying to manage a wildlife ecosystem. In order to try and solve these problems and ensure that the full economic benefit is derived from the wildlife, the 1972/76 joint UNDP/FAO Government financed (17.2 million shillings) Wildlife Management Project was set up. It operates in Kajiado District which has been selected as a test area since it is already a major viewing and hunting area.

Subsequent results can be used as a basis for wildlife development in other areas of Kenya.

Objectives

The objectives of the project are set out below:-

(i) To determine biological factors influencing wildlife populations, including trend and condition studies of the vegetation.

(ii) To investigate, develop as appropriate and to assist in implementation of wildlife utilisation programmes, including game viewing, sport hunting, direct cropping and marketing, game ranching and live animal capture.

(iii) To determine the degree of competition for food and water between the various species of wildlife, between wildlife and domestic livestock, and to establish their comparative efficiency of conversion of forage to meat, including if possible, zebra and wildebeest meat.

(iv) To evaluate the economic potentials for wildlife utilisation.

(v) On the basis of information generated by the project, to develop and implement in Kajiado District an extension programme to advise ranchers on how best to make use of wildlife in managing their land.

(vi) To identify needs for further wildlife research and management projects.

(vii) To provide wildlife inputs into land use plans for Kajiado District.

In the course of carrying out the above activities, training needs for counterpart personnel will be identified, and training will be provided either locally and/or abroad to enable counterparts to implement improved wildlife management policies.

The project shall implement any necessary improvements in organisation and practices of the Game Department in Kajiado District, and any necessary on-the-job training of the staff of

the Game Department in Kajiado District in the light of information generated by the project, to permit the Game Department to play the fullest possible role in the development of the District. In later years of the project, project personnel will provide advice and assistance to Game Department staff in other Districts where it is intended to replicate activities which have been successfully tested and implemented in Kajiado District.

It will be a purpose of the project to identify investible projects.

Spheres of Influence and Study

The spheres of influence and study of the Wildlife Management Project are reflected in the staffing which has been set out in the project document as follows:

Project Manager - A thorough knowledge, extensive experience and demonstrated ability in the fields of wildlife management research, administration and legislation is required. He is responsible together with Project Co-Manager for all phases of the project. He will, in cooperation with the Project Co-Manager, establish and maintain cooperative working relations between the project and the various Ministries of Government and with other organisations concerned with project activities. He is responsible for recommendations to government bodies concerning land use planning and wildlife development and for recommending development and training programmes to Government. Also he is responsible for the efficient operation of all personnal on the project, the preparation and distribution of applicable reports and other information, and will serve as the administrative head of the project.

Wildlife Biologist - He is responsible for planning and executing programmes on production operations in cropping, sport hunting and wildlife viewing. With Pilot Biologist he will

determine the wildlife population structure and production operations. He is responsible for application of biological feedbacks to project operations, and participates with the Habitat Ecologist, Economist and Veterinarian in design of information systems. He assists the Wildlife Extension Specialist in surveys and the design of communications programmes with ranchers. He also participates in assessment of alternative production systems and the preparation of recommendations for land use.

Resource Economist - He is responsible for economic aspects of the project, involving, but not limited to, accounting for costs and returns, marketing studies, studies of wildlife industries, studies of alternative production and marketing opportunities. He assists the economic planning agencies of the Government and private sectors in evaluating returns from wildlife development and taking these into account in planning procedures. He participates, with other project personnel, in the design and evaluation of production operations and information systems.

Wildlife Veterinarian - He is responsible for determining the influence of diseases, parasites, and nutrition on wildlife population levels. In cooperation with the Kenya Veterinary Service he develops standard methods of meat handling, inspection and hygienic practices. In collaboration with the Kenya Veterinary Service Research Laboratory, Kabete he investigates diseases and parasites in game in relation to livestock and human health problems.

Wildlife Habitat Ecologist - He is responsible for evaluating the habitat in terms of plant production, condition and trend. He assists in determining wildlife-livestock relationships, particularly in terms of food habits and grazing patterns. He collaborates with project personnel in setting cropping rates,

and assists in the development of techniques for surveys and planning.

Pilot Biologist - He is responsible for all aspects of operation of aircraft, including flight planning for aerial census, movement studies, herd structure and reconnaissance for trapping operations. With other personnel he carries out flights to accomplish the above and assists in computation and final preparation of results. He performs other biological aspects of the project when not engaged in flight activities.

The UNDP provides an expert to fill each of these posts and the Government of Kenya provides a counterpart. In addition UNDP provides specialist consultants, as required, for short periods.

In summary, then, the Wildlife Management Project is basically a wildlife utilisation project covering the economic, biological, technical and land planning aspects of wildlife development. To this end it is concerned with determining the optimum forms, levels and location of all the potential forms of wildlife utilisation and assisting the Kenya Government in bringing about an optimum pattern of land use in Kajiado District.

CONCLUSION

The preceeding discussion has served to outline the existing situation in the livestock and wildlife utilisation sectors and indicate the potential developments in these industries in order to set the picture. The remainder of the thesis is concerned with conceptualising these forms of land use with particular reference to Kajiado District.

TABLE I: INCORPORATED GROUP RANCHES IN KAJIADO DISTRICT
(AS AT 30TH APRIL, 1973)

NAME OF GROUP RANCH	FAMILIES	AREA IN HECTARES
Kiboko	66	15,870
OlKurkar	60	10,280
Maruaashi	71	18,546
Nbuko	89	18,477
Nbilini	64	14,723
Poka	30	8,926
Meman	322	39,760
Imeroro/Maabaru	334	19,483
Ilmamen	94	12,194
Emarti Ole Narau	91	13,211
Eranken	68	8,985
Arroi	113	18,692
Olkinos	106	6,020
Embolio	248	24,000
Emp Uyankat	76	15,270
Kimana/Tikondo	167	25,120
Oldonyonyokie	162	68,566
Kilonito	122	25,685
Rombo	512	38,265
	2,795	402,073

TABLE II: DISTRIBUTION OF SOME MAJOR WILDLIFE SPECIES AND LIVESTOCK BY ECOLOGICAL ZONE FOR THE DRY SEASON, AUGUST, 1973

	ECOLOGICAL ZONES									
	II		III		IV		V		District Total	
	%	No.	%	No.	%	No.	%	No.	No.	Biomass
Wildebeest	0	0	8.7	5,200	53.9	32,000	37.4	22,000	59,400	10,809,000
Zebra	0	0	2.9	800	34.9	9,700	62.2	17,300	27,800	6,304,000
Kongoni	1.3	200	13.0	2,100	62.7	10,100	23.0	3,700	16,100	1,844,000
Giraffe	0	0	3.0	200	38.8	2,600	58.2	3,900	6,700	4,591,000
biomass (kg)	0.1	21,000	6.4	1,496,000	46.5	10,942,000	47.1	11,087,000	-	23,548,000
Cattle 1/	0.7	4,800	2.3	16,100	38.4	268,700	58.6	410,300	700,000	151,200,000
Sheep & Goats 2/	0.5	2,600	2.0	10,300	42.1	220,500	55.4	289,700	523,000	14,121,000
biomass (kg)	0.7	1,112,000	2.3	3,754,000	38.7	63,999,000	58.3	96,455,000	-	165,321,000
Total biomass (kg)	0.6	1,133,000	2.8	5,250,000	39.7	74,941,000	56.9	107,542,000	-	188,869,000
biomass kg/ha		38.3		182.3		113.2		78.1		90.1 3/

1/ Distribution based on herd counts from aerial surveys. Population assumed to be 700,000.

2/ Distribution based on herd counts from aerial surveys. Population assumed similar to November, 1973 survey, with negligible death loss due to drought.

3/ When Grant's and Thomson's gazelle, impala, eland, ostrich, oryx and elephant are added, the average biomass is 92.82 kg/ha. Of this latter average, 85% is domestic stock, 15% wildlife.

TABLE I[III]: DISTRIBUTION OF MAJOR WILDLIFE SPECIES AND LIVESTOCK BY ECOLOGICAL ZONE FOR THE SHORT RAINY SEASON, NOVEMBER, 1973

ECOLOGICAL ZONES

	II		III		IV		V		District Total	
	%	No.	%	No.	%	No.	%	No.	No.	Biomass
Wildebeest	0	0	11.6	7,100	30.5	18,600	57.9	35,300	61,000	11,092,000
Zebra	0.3	100	5.6	2,000	13.3	4,800	80.8	29,100	36,000	8,193,000
Kongoni	0	0	1.3	300	72.6	17,500	26.1	6,300	24,100	2,752,000
Giraffe	0	0	0.6	55	24.9	2,200	74.5	6,600	8,855	6,028,000
biomass (kg)	0.1	25,000	6.5	1,835,000	28.5	7,989,000	64.9	18,215,000	-	28,065,000
Cattle 1/	0.4	2,300	0.6	3,500	35.8	201,600	63.2	356,600	564,000	121,824,000
Sheep & Goats 2/	0.8	4,300	2.9	15,000	28.3	147,900	68.0	355,800	523,000	14,121,000
livestock biomass (kg)	0.4	612,900	0.9	1,161,000	35.0	47,539,000	63.7	86,632,000	-	135,945,000
Total biomass 3/	0.4	637,900	1.8	2,996,000	33.0	55,528,000	64.0	105,047,000	-	164,010,000
biomass kg/ha		22.5		104.0		83.9		76.1		78.2

1/ Distribution based on herd counts from aerial surveys. Population estimated to be 564,000.

2/ Distribution based on herd counts from aerial surveys. Population estimate 523,000.

3/ District average biomass for the species listed here is 78.2 kg/ha. When Grant's and Thomson's gazelle, impala, eland, ostrich, oryx and elephant are added, the average biomass is 83.2 kg/ha. Of this latter average, 78% is domestic livestock and 22% is wildlife.

APPENDIX I[1]: RELATIONSHIP BETWEEN HUMAN POPULATION LEVEL AND HERD SIZE

There appears to be large discrepancies in the estimates of Kajiado District cattle population. For example, Murray Watson arrived at a figure of 690,000 in his 1970 aerial census but David Western (in conversation) was more inclined towards a figure of 500,000, on the basis that Kaputei supports a cattle population of 50,000 and is a comparatively fertile 10% of Kajiado District. Assuming that in a milk subsistence economy, 8 cattle per head is a high estimate and 5 cattle per head is low, the following figures indicate a feasible range of cattle population.

1969 census

Total population Kajiado District - 86,000

Population of Kajiado and Ngong townships - 3,500

Assume a further 2,500 (low) not dependent on cattle rearing
Therefore estimated range population - 80,000 people (high)

Number of cattle required for milk subsistence

8 cattle per person - 640,000 cattle
5 cattle per person - 400,000 cattle

a. Assume human range population increased at 2% p.a.

1973 - Number of cattle required to support 86,595 people on milk subsistence diet.

8 cattle per person - 692,760 cattle
5 cattle per person - 432,975 cattle

b. If human rangeland population increased at 2.5% p.a.

1973 - Number of cattle required to support 88,316 people on milk subsistence diet.

8 cattle per head - 706,528 cattle
5 cattle per head - 441,580 cattle

c. If human rangeland population increased at 3.3% p.a.

1973 - Number of cattle required to support 91,214 people on milk subsistence diet.

8 cattle per person - 729,712 cattle
5 cattle per person - 456,070 cattle

Population Projections by the Bureau of Central Statistics estimates the total population of Kajiado District in 1973 is 97,000 people. If we assume 90,000 (high) of these exist in a traditional milk subsistence economy, then the number of cattle required at

(a) 8 cattle per person is 720,000 head
(b) 5 cattle per person is 450,000 head

Thus, these figures emphasise the problems of trying to estimate the cattle population under the conditions which exist in Kajiado District.

APPENDIX I[II]: THE ORGANISATION OF HUNTING IN KAJIADO DISTRICT 1/

Wildlife Management Areas and Units

The District has been divided into Wildlife Management Areas and each of these subdivided into Wildlife Management Units. Each has been given a name and each a number for easy reference. A prefix letter "K" for Kajiado has been given each number to designate the District so as to avoid confusion with numbers still used for Controlled Area Blocks in the rest of Kenya.

A map indicating boundaries of Areas and Units is provided here as Map I[V].

Wildlife Management Areas

There are at present four Wildlife Management Areas in Kajiado District, primarily differentiating, so far as possible, ecological sub-divisions. Thus the number "20" series constitutes the Lower Rift Valley Wildlife Management Area, the "21" series the Athi-Kapiti Area, the "22" series the Central Kajiado Area and the "23" series the Eastern Kajiado Area.

There are no definitive biological or ecological boundaries which can separate Management Areas. One ecological type may phase into another and certainly there are movements of wild animals back and forth between areas. Thus, lines need to be somewhat arbitrary and have been drawn along boundaries used in land adjudication. These boundaries are not, however, wholly divorced from ecological lines. In many instances settlement of the Masai people by sections or sub-sections occurred naturally according to geographic and topographic features so that land adjudication often followed those same features upon which Area boundaries are properly delineated.

1/ As described in the "Hunt Management Programme, Kajiado District".

Wildlife Management Units (W.M.U.)

Each Wildlife Management Area has been subdivided into Wildlife Management Units. In most, but not all instances, boundaries of Units have been drawn to conform to adjudication boundaries. A Management Unit may take in one or several adjudicated ranches, but only rarely does a Unit consist of people or ranches from more than one sub-section of Maasai people.

Each Unit consists (or will when adjudication is completed) of group ranches, individual ranches and small parcels of holdings retained by the County Council.

Nairobi National Park and Amboseli Park have each been given Management Unit designations as easy references for wildlife management purposes.

Inasmuch as Unit K21b comprises the Kitengela which is under Government planning for tourism development it will not be open for hunting. Wildlife will be evaluated for this Unit and correlations made with Nairobi National Park and Units K21c and d.

Premises for Wildlife Management Area and Unit Planning

1. The District has been divided into more Management Units than the number of original Controlled Area Blocks. This has been done for two principle reasons:

   a. To provide better and closer application of all aspects of wildlife management to fit particular groups of Landowners. This should provide more equitable application of economic returns to particular landowners for wildlife produced on their lands.

   b. It will facilitate manipulation of hunter distribution for the purpose of better control of offtake.

2. Boundaries used here are provisional and as information and facts from all sources become available, adjustments will be applied.

3. Any alterations made will coincide with adjudication boundaries, particularly as they reflect sub-sectional groups of Maasai people. This has many ramifications which cannot be detailed here but this must receive top priority, especially in Unit boundary designations.

4. Wildlife management prescriptions are being developed for each Area and for each Unit. Offtake quotas will be established for each Area and, so far as possible, for each Unit. Offtakes will be for hunting, live trapping and cropping and, of course, these will be adjusted from time to time as accumulated information justifies such changes.

5. All wildlife management activities (including hunting) in Kajiado District by the Game Department and the Project will use the references to Wildlife Management Units. There are no longer Controlled Area Blocks in this District.

Licences and Fees

Any valid Full or 14-day Licence may be used for hunting in Kajiado District, but must be accompanied by a Chief Game Warden's Permit. This Permit is necessary because of special conditions applied for hunting on private lands. Full licence holders may also purchase and use Special Licences as provided in the Wild Animal Protection Act. In addition, booking fees and hunting fees for animals shot (as set out in Chapter III) are payable.

A landowner in Kajiado District may also purchase an Employee's Licence naming himself and/or a specific and regular employee who may use this Licence for hunting those species of animals permitted under a Full or 14-day licence (but not Special Licences) but only on the property of the landowner who takes out such a licence.

Animals taken will be considered a part of the quota established for that Unit. An Employee's Licence must be accompanied by a Chief Game Warden's Permit and a Wildlife Management Unit Permit. Booking fees and hunting fees are waived for a holder of an Employee's Licence. For any licence holder, regulations in the Wild Animals Protection Act applicable to each type or all licences (including Special Licences) apply as well as additional conditions of the Chief Game Warden's Permit.

A Wildlife Management Unit Permit is required of anyone hunting or booking a Unit for photographing in Kajiado District. This Permit provides for booking, as receipts for booking and hunting fees, and as a game register for each Unit.

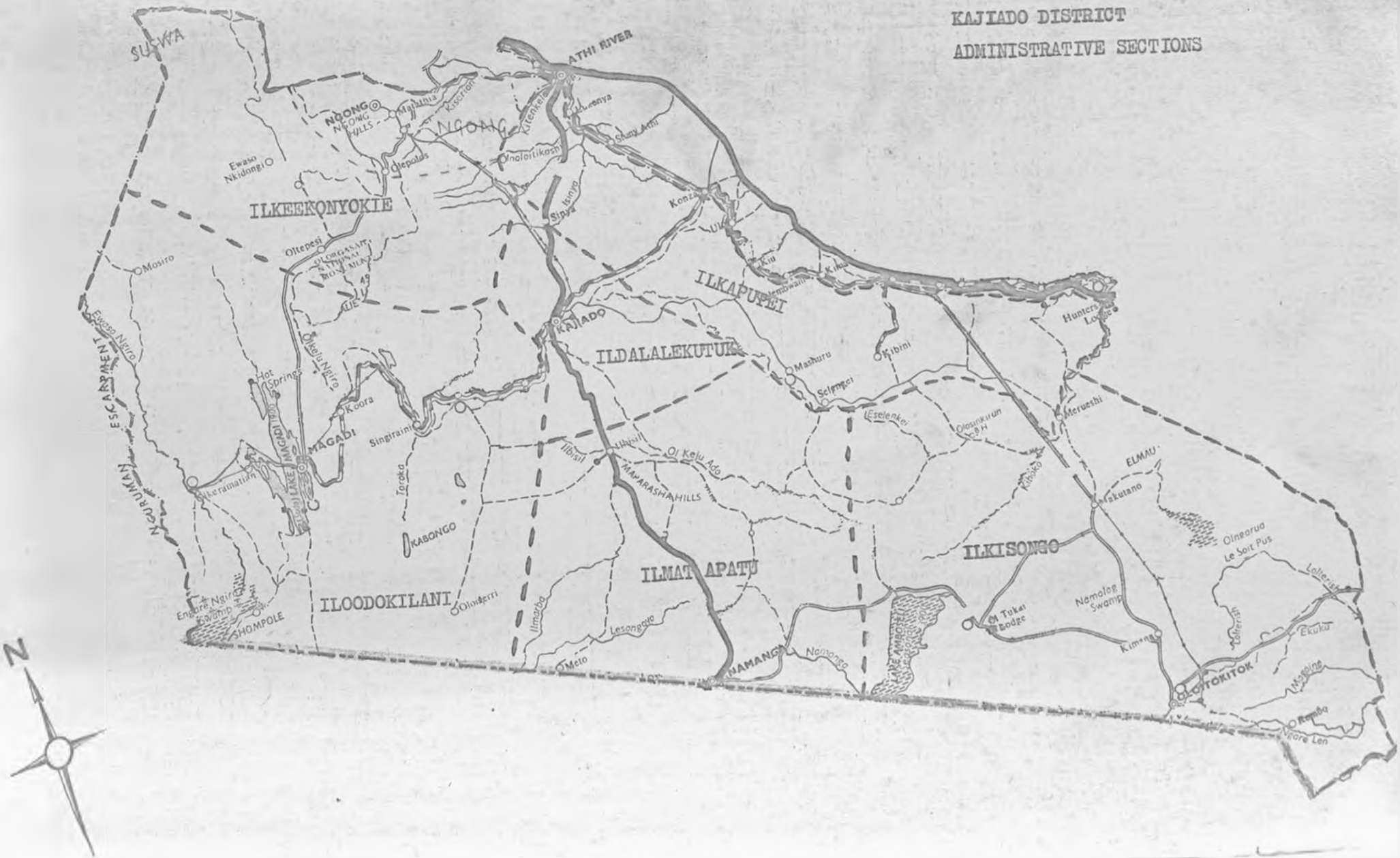
Concessionaire Hunting

Plans are being developed for making contracts with professional hunters for exclusive Unit bookings in a few Kajiado Management Units. There will be two major types of concession - one being for regular and major hunting safaris and the other for one-day hunting by non-residents. The exact procedures and conditions will be detailed in the contracts. Quotas for game harvests will be a part of the contract. Booking fees and hunting fees will be collected and dispersed to the landowners. Until such time as concessionaire contracts are negotiated, regular hunting bookings will be accepted. As contracts are finalised hunters will be so notified at the time they may request bookings for those Units. There will most likely be opportunities for short hunting safaris into the concession Units but all arrangements will have to be made through the Professional hunter organization who has the contract.

MAP I[I]

KAJIADO DISTRICT

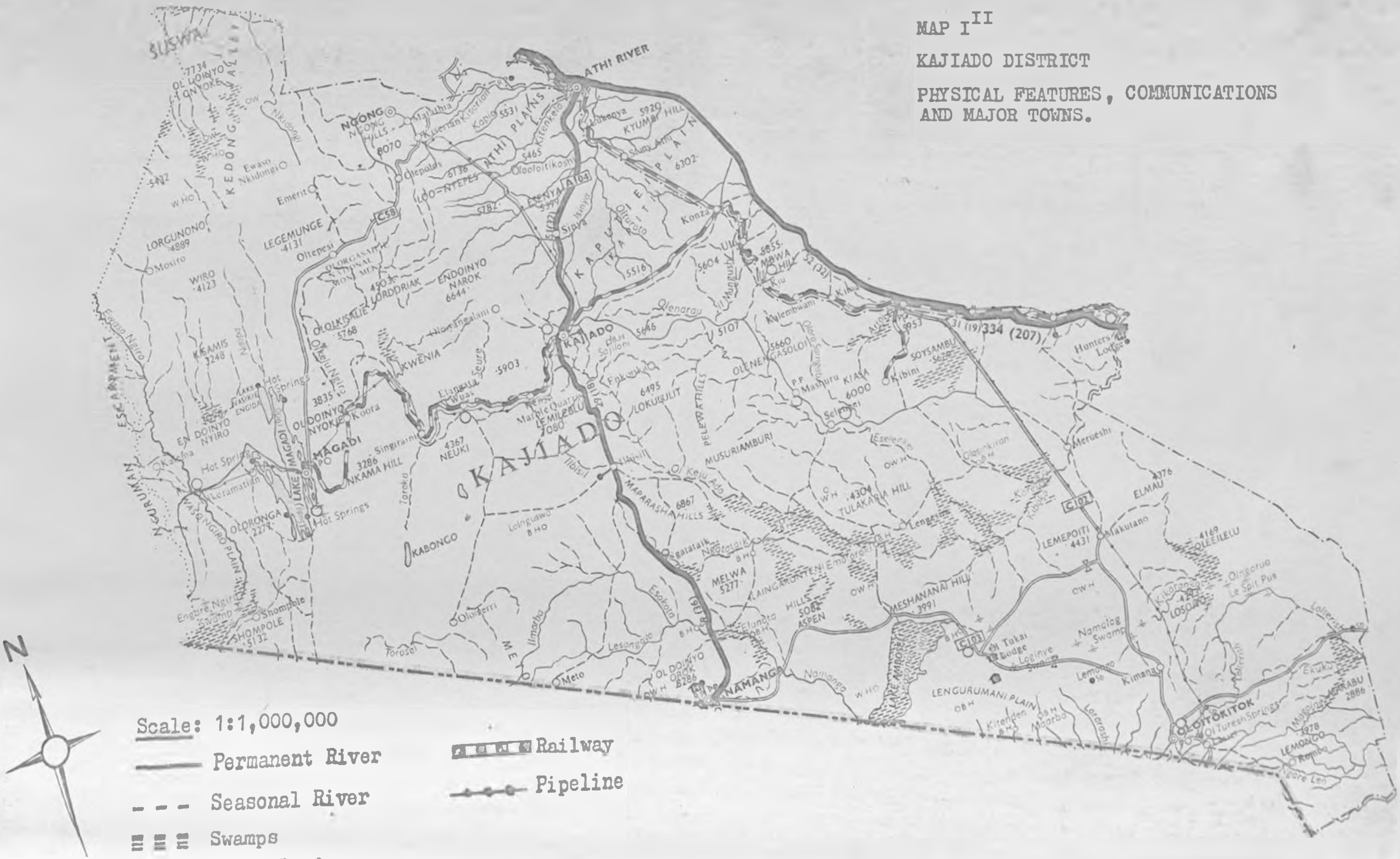
ADMINISTRATIVE SECTIONS



MAP I[II]

KAJIADO DISTRICT

PHYSICAL FEATURES, COMMUNICATIONS AND MAJOR TOWNS.



Scale: 1:1,000,000

Permanent River

Seasonal River

Swamps

Major Road

Minor Road

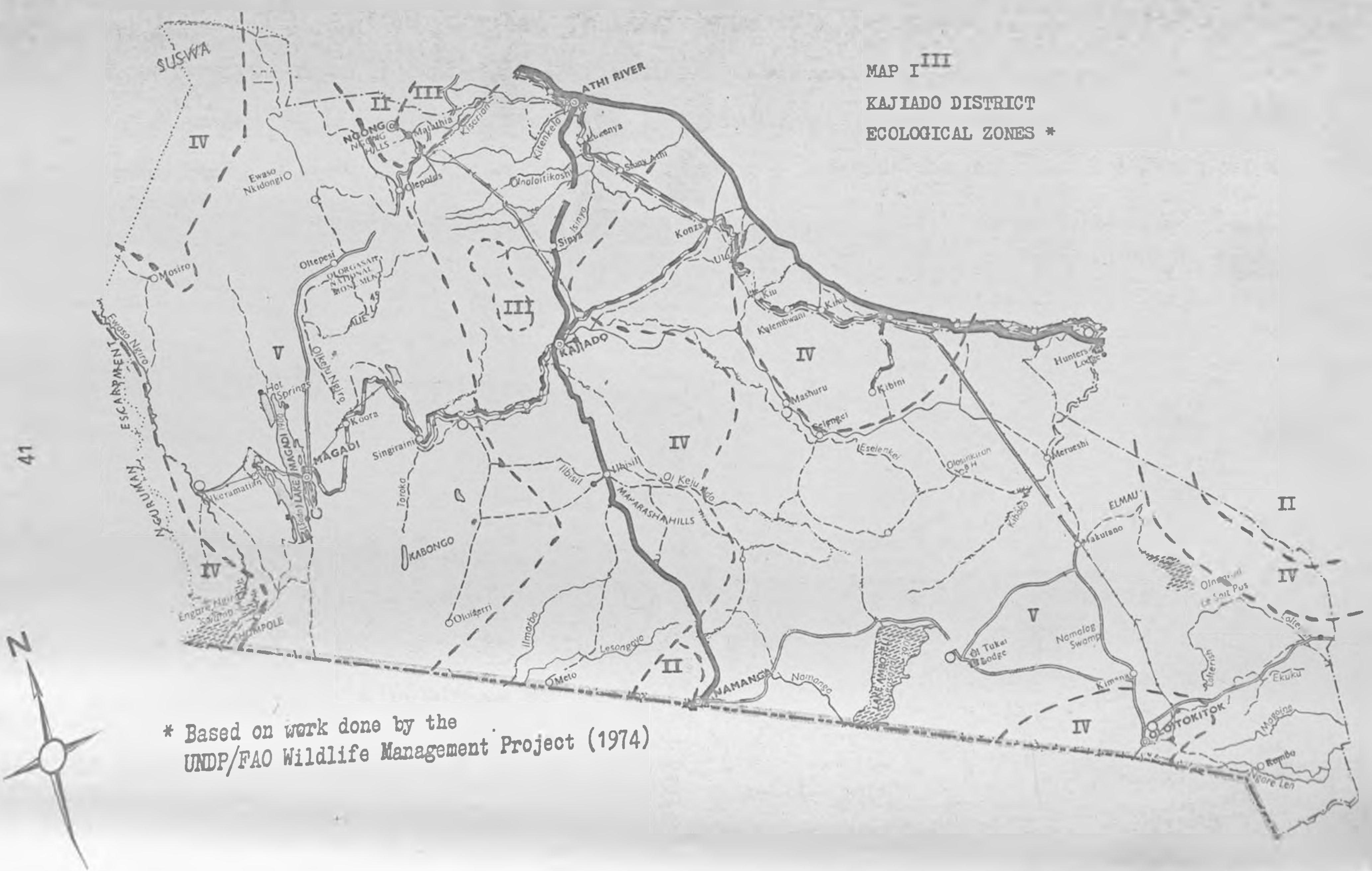
Railway

Pipeline

MAP III

KAJIADO DISTRICT

ECOLOGICAL ZONES *



* Based on work done by the UNDP/FAO Wildlife Management Project (1974)

MAP I[IV]

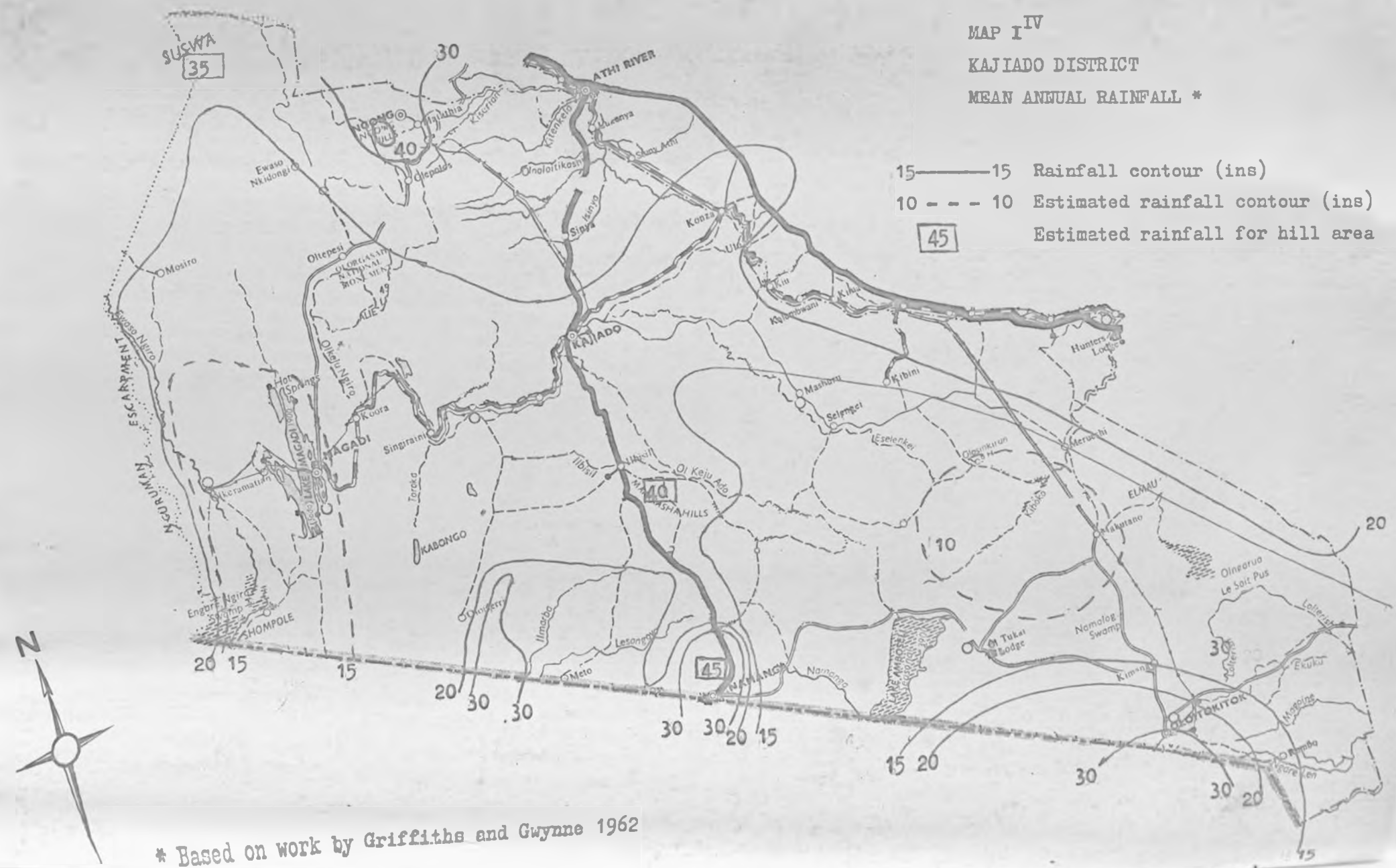
KAJIADO DISTRICT

MEAN ANNUAL RAINFALL *

15———15 Rainfall contour (ins)

10 - - - 10 Estimated rainfall contour (ins)

45 Estimated rainfall for hill area



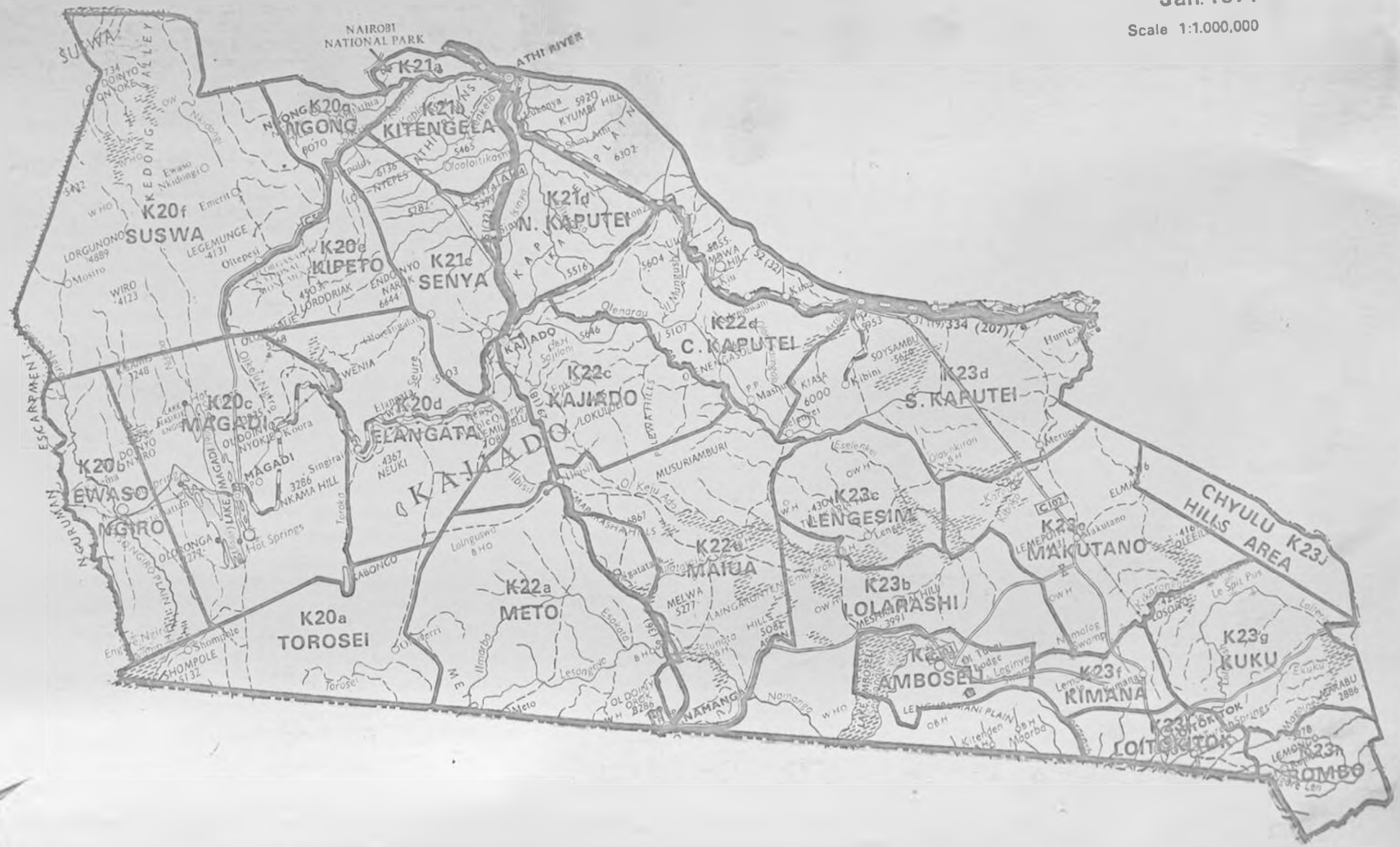
* Based on work by Griffiths and Gwynne 1962

KAJIADO DISTRICT

Wildlife Management Units

Jan. 1974

Scale 1:1,000,000



CHAPTER II

AN ANALYSIS OF POTENTIAL CATTLE OFFTAKE RATES AND POTENTIAL FINANCIAL RETURNS

INTRODUCTION

Currently the majority of information on the structure of, and offtake rates from, the traditional Maasai cattle herds in Kajiado District is the result of personal estimates based on varying degrees of local knowledge. In particular, there seems to be little data on potential offtake rates by the Maasai, if they change to cattle breeding for the commercial production of beef animals from their traditional methods of utilising their herds mainly for milk production with low levels of offtake for sale and consumption on the range. I have been unable to find any attempt to adopt a purely theoretical approach which tests the feasibility of these estimates which appear only to be based on informed guesswork.

My original intention in this chapter was to carry out a theoretical examination of the offtake levels and financial returns which might be achieved given some livestock development in Kajiado District. However, for commercial beef production, offtake must be in terms of young animals producing good quality meat and not animals from a variety of age groups as is the current Maasai practice. Hence, movement from traditional management practices to commercial production of uniform animals will involve a change in herd structures. However, since milk is one of the main components of the Maasai diet it was decided to include, in the analysis, the effect of any herd development on the percentage of breeding females in the herd, and hence milk production.

Any change in herd structure which also results in a changed level of milk production, must be brought about slowly. Firstly, the author estimates that the retail value of milk produced by the existing herds of Maasai cattle might be evaluated as highly as 93 million shillings (see Appendix II[1]) and any change in herd structure without an accompanying change in milk production per cow will affect this significant factor in the Maasai economy.

Secondly, any development which drastically and quickly reduced the proportion of breeding females and hence milk production would result in a sharp increase in demand for substitute foods by the Maasai using their cash incomes from commercial cattle production. Thus local inflation of food prices could occur. Thirdly, substitutes for milk need to be introduced slowly to give the Maasai time to change their tastes and food preference patterns.

This chapter falls into three Sections:-

Section I is concerned with an analysis of potential offtake rates and is composed as follows:-

Firstly, the methodology is outlined.

Secondly, the basic assumptions of this analysis are described.

Thirdly, the variables which effect herd structure are defined and appropriate ranges of values determined.

Fourthly, potential offtake rates are computed using the values of the variables outlined above.

Fifthly, an analysis of the relationship between the percentage of the total herd available for sale and the percentage of breeding females in the herd for a given variable is carried out.

Section II is based on Section I and considers potential financial returns.

Firstly, formulae to determine potential revenue from a cattle ranching activity are set out.

Secondly, the assumptions are outlined.

Thirdly, the formulae for determining potential revenue are applied to the data built up in Section I and the results are analysed.

In Section III some associated investment problems are discussed. Various forms of investment appraisal techniques are outlined and suitable form is applied to the data in Section II to exemplify the problems of using these techniques in the given situation. Finally, investment patterns are considered.

SECTION I

ANALYSIS OF POTENTIAL OFFTAKE RATES

A METHODOLOGY

A feature of this analysis is that each category of animal is not considered in terms of actual numbers but as a percentage of the total herd. There are several advantages to this approach. Firstly, it enables the analysis to be carried out without knowledge of the precise numbers involved. This is particularly significant because of the lack of information about the actual cattle numbers as discussed in Chapter I. Secondly, it can be used at either ranch or district level since the percentage is easily converted to a real number if the total number of animals is known. Thirdly, the concept of carrying capacity can be included. Overstocking is one of the major management problems in Kajiado District at present and this use of percentages focuses on a maximum carrying capacity of 100%. Hence, if the carrying capacity in terms of stock units, of a particular area is known this can be used, in conjunction with data which expresses each age group, and sex category firstly, as a percentage of the total herd and secondly, as a fraction of a stock unit, to determine the number of animals in each category and in total. In this case a maximum carrying capacity is defined as the greatest population of livestock which can be permanently (i.e. during the dry season as well as the wet season) maintained on a given area of land without a decline in the status of the habitat. Thus, a population which exceeds 100% of the maximum carrying capacity constitutes overstocking.

The approach adopted was to firstly list all the variables which affect herd structure. From this, formulae for calculating the numbers of breeding females as a percentage of the total herd (f) and the percentage of total herd available for sale in a given age group (o) were developed. For each of the variables involved a fairly optimistic but reasonable value based on knowledge of current management levels was selected and the percentage of breeding females (f) and the percentage of the herd available for sale (o) were computed. Using this as the basic set of values, higher and lower values of each variable were taken in turn and the percentage of breeding females (f) and the percentage of the herd available for sale (o) computed accordingly. For each set of variables the percentage of breeding females (f) and the percentage of the herd available for sale (o) were calculated for sale at five different ages. A set of graphs for each variable was then drawn up so that the relationship between the range of values for a given variable and the percentage of breeding females (f) and the percentage of the herd available for sale (o) and age sale could be examined.

B ASSUMPTIONS

It is assumed that, firstly, cattle for beef production will be bred and raised on the range, hence the herd will be composed of bulls, breeding females and young animals being reared for sale or replacement. Secondly, there is a financially optimum age at which slaughter stock should be sold and all young animals apart from those required for replacement will be sold at this age.

C VARIABLES AFFECTING HERD STRUCTURE

The figures discussed in this part are based on information given in conversation by members of the Agricultural Finance Corporation and the Zoology Department of Nairobi University.

Fraction of breeding herd calving in any year (c)

Fertility is greatly affected by drought, therefore, it is assumed that water development will assist in nullifying the effects

of drought. However, water development will not increase forage and there are few under-utilised areas in Kajiado District to exploit especially in a drought. Thus, 0.67 of the breeding herd calving in any given year is taken as a reasonable estimate of what can be achieved annually under fairly good management. Estimates suggest that the figure is currently lower than this in the less favourable areas, therefore, a low figure of 0.5 is taken and a high of 0.75 used, although in the light of the above discussion this is not considered a currently feasible figure. In practice this figure will vary from year to year depending on the level of rainfall which influences the level of primary vegetation production and hence the physical state of the breeding females.

Survival rate of calves (k)

This variable is also influenced by rainfall but livestock planners hope that water development will reduce the effect of variable rainfall. The author believes this assumption is a fallacy since increased watering points will not increase primary vegetation production and hence the cow's ability to produce milk. Disease control and improved management should significantly improve the calf survival rate. The most likely estimate of the calf survival rate in average to good conditions is taken as 0.85. High figures of 0.9 and 0.95 are used while a low of 0.8 is taken although in unfavourable conditions at current management levels the figure is likely to fall much below this.

Age of first parturition (p)

Young females are assumed to calve down for the first time in the 3-4 year old age group (i.e. p = 3). A management problem occurs in the form that economically it is desirable for breeding animals to calve down for the first time as soon as possible, since, as the following analysis reveals the younger the age of first parturition the more advantageous the effect on the percentage of animals available for sale and the percentage of breeding females.

Therefore, when calculating potential offtake rates in the tables a high of 'p' = 2 has been used. However, it is necessary from a biological standpoint for the cow to be physically mature when she produces her first calf. Given the ecological conditions of Kajiado District and hence the late maturing age it is deemed desirable to raise, not lower the age of first parturition, therefore, 'p' = 4 is also calculated and is used as a 'target' value in the discussion.

Age of sale (a)

The age of sale will vary accordingly to the management techniques. If the animals are to be sold in a finished condition from the range then a possible range of figures would be the 3-4, 4-5 and 5-6 year old age groups (i.e. a = 3, a = 4, a = 5). On the other hand if cattle are to be finished elsewhere such as an intensive unit then depending on the method of finishing they could be sold in the 1-2, 2-3 or 3-4 year old age groups, depending on the method of finishing.

Replacement rate per annum of breeding females (h)

This includes replacement of infertile animals and regular annual losses through natural causes. Since the number of animals available for sale will be maximised by minimising the number of animals required for replacement, breeding females should be kept their full active breeding life. A basic estimate of 0.14 is used with a high of 0.17 and a low of 0.12.

Bull:breeding female ratio (i)

A reasonable estimate of 0.1 (i.e. 10 breeding cows per bull) is taken with a high of 0.07 and a low of 0.2.

Survival rate of immatures (s)

The basic estimate of a reasonable overall annual achievement is 0.95 with a high of 0.98 under good management and livestock development investment in the form of disease control and water development. A low figure of 0.9 is taken.

These variables can be combined to calculate

(i) the percentage of the herd available for sale (o)

$$o = \frac{100\,(g\,k\,e^{a} - h)}{\left[\, cd\,(1+e \ldots e^{a}) + (p-a)h+1+j \,\right]}$$

and (ii) the percentage of the herd composed of breeding females

$$f = \frac{100}{\left[\, cd\,(1+e+ \ldots e^{a}) + (p-a)h+1+j \,\right]}$$

(The derivations of the above formulae are set out in Appendix II[II]).

D POTENTIAL OFFTAKE RATES

Under the traditional Maasai method of herd management the percentage of breeding females in the herd is high. Estimates, given in conversation, range from 42% (S. Meadows) to 55% (D. Western). In favourable conditions this allows a large, rapid increase in herd numbers. This is illustrated in Table II[I] which gives the annual percentage increase in herd size for a range of values of calving intervals, calf survival rates and percentage of breeding females in the herd. From here it is easy to say that each year a certain percentage (say x%) of the herd is lost through natural causes and thus the percentage of total herd available for offtake, assuming no increase in herd size, is given by o = i-x (where i = cdf). However, such an approach ignores one crucial fact, and that is that such offtake rates are only possible if the animals taken off represent a cross-section of the herd structure. The answers given by this method are highly misleading when estimating the potential offtake of young animals of a uniform age and this is what we must be concerned with when talking about developing commercial beef production."

Table II^{II} gives the potential offtake rates for various combinations of the value of the relevant variables which are set out in the preceding section. The set of values in combinations 1–5 are deemed to be the most feasible figures obtainable in the early stages of livestock development. For the set of basic values (the fraction of breeding females calving per annum = 0.67, calf survival rate = 0.85, age of first parturition = 3, replacement rate = 0.14, sex ratio = 0.1 and immatures survival rate = 0.95) the potential offtake rate ranges from 7.3% to 16.1% of the total herd as the age of sale falls from 5 years to 1 year. Combinations 6–70 give the potential offtake levels for variations in the values of each variable from the basic set of values. However, combinations 71–80 prove to be the most illuminating. Combinations 71–75 combine the most optimistic value of each variable for the five potential ages of sale. Even so, offtakes only ranges from 10.9% to 22.2%. Taking this to its logical conclusion the maximum technically possible values of each variable is computed for the five potential ages of sale (combinations 76–80) and in these cases offtake rates range from 13.3% to 28.6%. It should be pointed out that this last set of figures represents the very highest level of management in the most favourable conditions and in the author's opinion is never likely to be achieved in Kajiado District even with the considerable livestock development planned under the World Bank Livestock Development Plan.

B ANALYSIS OF THE RELATIONSHIP BETWEEN THE PERCENTAGE OF TOTAL HERD AVAILABLE FOR SALE AND THE PERCENTAGE OF BREEDING FEMALES

For each variable the relationships between the percentage of breeding females (f) the percentage of the herd available for sale (e) and the age of sale (a) for differing values of that variable have been expressed in a series of graphs. (See graphs II^{I} - II^{VI}).

Graphs II_A^{I-VI} and II_D^{I-VI}

As the value of the variable is improved the potential offtake rate increases. This is true for all the variables except for the age of first parturition.

For all variables except the survival rate of immatures the lower the age of sale the greater the effect on the potential offtake rate of changing the value of the variables (i.e. the gradient of the lines in Graph II_A^{I-VI} decreases as the age of sale increases).

As the age of sale falls, the greater the effect on the potential offtake rate of lowering the age of sale even further for all variables e.g. the increase in the potential offtake rate is less when the age of sale falls from 5 years to 4 years than when it falls from 2 years to 1 year, except for the age of first parturition where the effect is negative.

Graphs II_B^{I-VI} and II_E^{I-VI}

Improving the value of the replacement rate (when 'a' is greater than 3) the age of first parturition, the fraction of the breeding herd calving per annum, the calf and immatures survival rates reduces the percentage of breeding females. When a = 3, and change in the replacement rate over the given range has no effect on the percentage of breeding females and improving the value of the replacement rate (when 'a' is less than 3) and the sex ratio results in an increase in the percentage of breeding females.

The lower the age of sale the less the percentage of breeding females is reduced when the replacement rate (when 'a' is greater than 3), the fraction of females calving per annum, the calf and immatures survival rates are improved. The lower the age of sale the more the percentage of breeding females is increased when the values of the replacement rate (when 'a' is

less than 3), the sex ratio are improved and decreased when the age of first parturition are improved. When the age of sale is 3 years the replacement rate has no influence on the percentage of breeding females.

As the age of sale falls the percentage of breeding females increases for any given value of the variables. This increase in the percentage of breeding females is greater, the lower the age of sale, except for the age of first parturition where the percentage of breeding females more than proportionately decreases. e.g. the increase in the percentage of breeding females as the age of sale falls from 5 years to 4 years is less than the increase when the age of sale falls from 2 years to 1 year.

Graphs II_D^{I-VI} and II_E^{I-VI}

Improving the value of the variable has greater absolute effect on the percentage of breeding females than the proportion of the herd available for sale, for all variables (i.e. the curves are further apart in Graph II_E^{I-VI} than II_D^{I-VI}.

Lowering the age of sale has a greater effect on the absolute value of the percentage of breeding females than the absolute value of the percentage of the herd available for sale. (i.e. curves are flatter in Graph II_E^{I-VI} than II_D^{I-VI}.

Graph II_C^{I-VI}

Graphs II_A^{I-VI}, II_B^{I-VI}, II_D^{I-VI} and II_E^{I-VI} are combined in Graph II_C^{I-VI}. Thus the solid lines show the relationship between the percentage of herd available for sale and the percentage of breeding females when the age of sale is constant for a range of values of the given variable. The dotted lines indicate the relationship between the percentage of herd available for sale and the percentage of breeding females for a range of values of when the value of the variable is held constant.

As the value of the sex ratio and the replacement rate (when 'a' is less than 3) is improved both the percentage of herd available for sale and the percentage of breeding females increase. As the age of first parturition is improved the percentage of herd available for sale and the percentage of breeding females falls.

As the values of the calf and immatures survival rates, the fraction of the breeding herd calving per annum and the replacement rate (when 'a' is greater than 3) is improved so the percentage of animals available for sale increases and the percentage of breeding females decreases.

The lower the age of sale the greater the positive effect on the percentage of animals available for sale and the less the negative effect on the percentage of breeding females when the calf and immatures survival rates, the fraction of breeding females and the replacement rate (when 'a' is greater than3) are improved. The lower the age of sale the greater the positive effect on the percentage of herd available for sale and the less the positive effect on the percentage of breeding females when the sex ratio and the replacement rate (when 'a' is less than 3). As the age of first parturition is improved, there is a negative effect on both the percentage of the herd available for sale and the percentage of breeding females and this effect is greater, the lower the age of sale.

As the age of sale falls for any given value of the variable so both the percentage of herd available for sale and the percentage of breeding females increase.

Conclusions from above analysis

The above analysis indicates that taking the values for each variable over a feasible range it is advantageous to lower the age at which animals are sold for three reasons. Firstly, lowering age of sale has a greater effect on the percentage of the herd available for sale (o) than a feasible improvement in the value of the survival rate of immatures (e) (when 'a' is less than 2), the survival rate of calves (k), the replacement

rate of breeding animals (h) the bull breeding female ratio (j) but in the case of the age of first parturition (p) this effect is negative. When the age of sale is greater than two years, substantial improvements in the survival rate of immatures (which can be read off from Graph II_A^V given the appropriate values) are necessary to provide an increase in the percentage of animals available for sale which would be greater than the increase provided by lowering the age of sale by one year. Secondly, the effect on the percentage of animals available for sale by improving the value of a given variable is greater the lower the age of sale except for the age of first parturition this effect is negative. Thirdly, lowering the age of sale results in an increase in the percentage of breeding females as well as the percentage of animals available for sale.

CONCLUSION

Two major points emerge. Firstly, given the assumed method of management set out earlier in the paper and taking optimistic values of the variables involved, the potential offtake rates are found to be relatively low; not over 10% unless the age of sale is less than three years for most of the combinations computed. These rates are much lower than those which might be anticipated by simply computing the annual increase in herd numbers. This is because we are concerned with removing uniform animals from the herd and not a cross-section of the population. This is a trap into which livestock planners often seem to fall when calculating potential offtake rates and thus high estimated offtake rates should be viewed with suspicion. Secondly, the advantageous effects of lowering the age at which animals are sold is clearly illuminated. The effect of improving the value of a variable is greater the lower the age of sale, and also, lowering the age of sale results in an increase in both the percentage of the total herd available for sale except for the

age of first parturition where for the biological reasons stated above it is advantageous not to lower, and probably to raise, the value of this variable, thus giving a negative effect.

SECTION II

DETERMINATION OF POTENTIAL REVENUES FROM CATTLE RANCHING

A Development of Potential Ranching Revenues Formulae

Potential ranching revenue formulae can be built up and used to evaluate the value of the ranching activity as follows. The subsequent section analyses this data.

Let P_m be the price of milk/gall.

m be the total milk production (galls), per lactation for human consumption.

P_s be the sale price of slaughter stock (for beef).

o be the percentage of herd available for sale as slaughter animals.

P_c be the sale price of cull cows

f be the percentage of herd composed of breeding females.

h be the replacement rate of breeding stock.

c be the fraction of breeding females calving per year.

n be $\frac{\text{total no. of animals in the herd}}{100}$

V be operational (variable) costs (other than labour) per hundred animals.

L be labour costs per hundred animals.

I be the level of capital investment.

r_1 be the rate of interest $\frac{}{100}$

Thus the revenues from a cattle ranching activity can be defined as follows:-

Total revenue from the sale of slaughter stock (beef)

$$R_s = P_s \, o \, n$$

Total revenue from the sale of cull cows

$$R_c = P_c \, f \, h \, n$$

Total revenue from sale of slaughter and cull animals

$$R_{s+c} = P_s \, o \, n + P_c \, f \, h \, n$$

Total value of milk production

$$R_m = P_m \, m \, f \, n$$

Total value of ranching activity

$$R = P_s \, o \, n + P_c \, f \, h \, n + P_m \, m \, f \, n$$

Net revenue from sale of slaughter and cull stock excluding labour costs

$$R^1_{s+c} = P_s \, o \, n + P_c \, f \, h \, n - V \, n$$

Net value of ranching activity excluding labour costs

$$R^1 = P_s \, o \, n + P_c \, f \, h \, n + P_m \, m \, f \, n - V \, n$$

Net revenue from sale of slaughter and cull stock including labour costs

$$R^{11}_{s+c} = P_s \, o \, n + P_c \, f \, h \, n - V \, n - L \, n$$

Net value of ranching activity including labour costs

$$R^{11} = P_s \, o \, n + P_c \, f \, h \, n + P_m \, m \, f \, n - V \, n - L \, n$$

Determination of the Optimum Age of Sale

Obviously, the optimum age of sale is the age of sale which yields the largest net revenue and for any given situation the optimum age of sale can be empirically determined using the preceding formulae as follows:-

Firstly, empirically determine the values of the variables which influence herd structure as given in Section I of this Chapter.

Secondly, use the method given there to calculate breeding females as a percentage of total herd and the percentage of herd available for sale.

Thirdly, empirically determine milk yields, prices of slaughter and cull stock, veterinary, dipping and any other variable costs and labour costs.

Fourthly, use data from 2 and 3 above and formulae given in Part A of this Section to calculate net revenue at each possible age of sale.

Fifthly, the optimum age of sale is the one which yields the greatest revenue.

B Assumptions

In order to calculate the potential revenues from the cattle ranching activity, various assumptions have been made. Firstly, prices and costs are assumed as follows:-

The value of slaughter and cull stock, based on Agricultural Finance Corporation figures for 1974 are an average of high and low estimates and are as follows:-

1 year old	75/- per head
2 years old	190/- per head
3 years old	275/- per head
4 years old	350/- per head
5 years old	390/- per head
cull stock	375/- per head

The value of subsistence milk is taken as Shs.2/80 per gallon. A full discussion of the problem of evaluating subsistence milk occurs in Chapter IV.

Veterinary costs of Shs.20/- per head per year and dipping costs of Shs.10/- per head per year are based on Agricultural Finance Corporation estimates.

Labour costs are assumed at the commercial rate of one herder per 150 cows at Shs.120/- per month.

Secondly, milk yield per lactation is assumed to be 114 gallons. Therefore, the value of subsistence milk per lactation is taken to be Shs.319/- approximately.

Thirdly, only veterinary and dipping costs are included as variable costs in the typical traditional set up.

Fourthly, the arguments as to whether the value of subsistence milk should be included or excluded in the value of the ranching activity are set out in Chapter IV. In this Chapter both sets of figures have been calculated.

Fifthly, likewise the problem of whether or not to include labour charges, and if so at what price, is discussed in Chapter IV. Again both sets of figures have been set out in the tables.

Sixthly, all the potential revenues have been calculated on the basis of a herd of one hundred animals.

C Analysis of Potential Ranching Revenues

Based on Table II[II] and using the assumptions given above, Table II[III] sets out potential revenues per head of one hundred animals for the eighty combinations of values of the variables which influence herd structure. Two significant points are apparent in this data. Firstly, if the value of milk production is excluded and the cost of labour included, then for all the combinations which have the age of sale at one year old net revenue is negative. If milk production is included, or labour costs are excluded or the age of sale is greater than one year old then net revenue is positive. In practice the traditional Maasai economy would not suffer a negative cash flow because labour is not usually paid for in cash but in kind, particularly in the form of subsistence milk.

Secondly, the imputed value of milk production is significantly greater than revenues from the sale of slaughter and cull animals for all the combinations. This observation is typical of the situation which arises when one is dealing with imputed as opposed to real values. In this case I have chosen a value for subsistence milk production which results in the value of milk being greater than the value of sales. If different criteria were adopted for pricing milk, the situation may either be exaggerated or reversed depending on the criteria.

At this point it is interesting to discuss the shapes of these revenue curves when age of sale is plotted against revenue.

The total revenue from slaughter stock (R_s) is parabola shaped with a maximum at four years old for all combinations. Up to four years old the increase in revenue per animal for selling a more mature animal more than offsets the reduction in potential offtake. After four years old this situation is reversed.

The total revenue from the sale of cull cows (R_c) is an inverted parabola for all combinations because as the age of sale rises a lesser proportion of the herd is composed of breeding females resulting in fewer cull animals.

The revenue from the sale of cull and slaughter animals, in total (R_{s+c}) net of variable costs ($R^{\prime}_{s+c}$) and net of variable costs and labour $R^{\prime\prime}_{s+c}$) are parabola shaped for all combinations with a maximum at four years. These graphs are based on the addition of the above two graphs. Up to four years the increase in revenue from selling beef slaughter animals more than outweighs the fall in revenue from the sale of cull animals. After four years R_s and R_c decline, and therefore, R_{s+c} will also decline. Likewise $R^{\prime}_{s+c}$ and $R^{\prime\prime}_{s+c}$ fall as well.

The total revenue from the sale of milk (R_m) is an inverted semi-parabola for all combinations because as age of sale rises the proportion of the herd composed of breeding females declines and hence milk production falls.

The revenue from the whole ranching activity in total (R), net of variable costs (R^{I}) and net of variables and labour costs (R^{II}) are all inverted semi parabolas for all combinations except for 6-10 and 71-75 which are parabola shaped with a maximum at two years. This occurs because in all cases except for 6-10 and 71-75 the fall in revenue from cull cows and the fall in the value of milk production is greater than the rise in revenue from slaughter animals. These two exceptions arise because given those particular sets of variables the changes which occur in herd structure if the age of sale is raised are such that up to two years the fall in value of milk produced and revenue from sale of culls is more than offset by increased revenue from sale of slaughter stock. If age of sale is extended beyond two years the situation is reversed.

Combinations 1-10 have been plotted on graphs II^{VII} and II^{VIII} to exemplify the shapes of the above curves and the way in which they lie in relation to each other.

This analysis is highly significant because if we accept the assumptions that have been made and if the value of milk production is excluded then the optimum age of sale is four years old for all the combinations of values in Table II^{III}. On the other hand, if the value of milk is included then the optimum age of sale would be one year old except for combinations 6-10 and 71-75 for which two years is the optimum situation. It should be noted that net revenue from sale of animals at one year old is negative if labour charges are included. Thus, there would be a negative cash flow because by definition the value of subsistence

milk does not enter the monetary cash flow of a pastoralist. However, as pointed out previously, this negative cash flow will only arise if labour is paid in cash.

The influence of a change in the value of a variable on Potential Revenue

An increase in value of the following variables represents an improvement in herd performance: the fraction of the breeding herd calving in any given year, (c) the survival rate of calves (k) and immatures (e). A lowering of the replacement rate of breeding animals (h) and bull:cow ratio (j) only constitutes an improvement if the existing fertility levels are maintained. Depending on the type of cattle in question and local conditions there will be a value for these two variables. For biological reasons the age of first parturition (p) should not be too low, probably around 3-4 years but varying according to type of cow and local conditions. On the other hand for economic reasons a cow should begin to reproduce as soon as it is mature.

Bearing these points in mind Table II[III] can be analysed as follows:-

The total value of the sale as slaughter animals (R_s) - an increase in the value of the calf survival rate, the fraction of breeding females calving per annum and the immatures survival rate and a decrease in the replacement rate of breeding stock, the sex ratio and the age of first parturition result in more animals being available for slaughter and hence increase in revenue.

The total value of the sale of cull cows (R_c) - an increase in the value of the variables except the replacement rate of breeding stock results in a reduction in the percentage of the herd composed of breeding females and hence the potential revenue from the sale of cull cows decreases. An increase in the replacement rate obviously results in increased revenue.

The total value of the sale of cull and slaughter cows (R_{s+c}) - this is a combination of the above revenues and for all variables the increase in R_s more than outweighs the decrease in R_c.

The value of the sale of cull and slaughter cows net of variable costs (R^{1}_{s+c}) and net of variable and labour costs (R^{11}_{s+c}) - these revenues are based on R_{s+c} as defined above and therefore follow the same pattern.

The total value of milk production (R_m) - as the value of the calf and immature survival rate increase and the replacement rate falls the size of the breeding herd falls and hence milk production falls. As the fraction of breeding females calving per annum rises and the age of first parturition falls, the amount of animals in milk and hence total milk production rises. As sex ratio falls the size of the breeding herd increases and so potential milk production increases.

The value of the ranching activity in total (R), net of variable costs (R^{1}) and net of variable and labour costs (R^{11}) - the same pattern exists for these revenues (R^{1} and R^{11} being derived from R) as for R_m. This is because R is the sum total of R_s, R_c and R_m and in all cases R_m is so large it outweighs the effect of R_s and R_c.

An analysis of this type is useful in investment appraisal since the improvement of the value of any variable implies a capital cost. It is obviously desirable that the greatest increase in net revenue should be achieved with the minimum capital investment. Thus the above analysis assists in focusing on those variables which have the greatest influence on net revenue.

SECTION III

SOME INVESTMENT PROBLEMS

The cattle industry is not in a static situation but is currently undergoing change by investment, particularly through the World Bank Livestock Development Plan. However, there are considerable problems in finding a suitable investment technique and in applying it. Hence, this section looks at some of the more common investment appraisal techniques and examines the way in which they can be applied to the situation existing in Kajiado District.

A The Relationship between Capital Investment and Change in Revenue

Starting from first principles the effect of investment on revenue can be expressed graphically as shown in Figures II^{I} and II^{II}.

The concept of marginal returns (i.e. the change in revenue as a result of a small increase in capital investment) is particularly significant here. This is because as a result of the following discussion of some of the common investment appraisal techniques it will be seen that an investment criteria based on the marginal approach is one of the most suitable in the given situation.

B Investment Criteria

There are a variety of ways in which a project can be evaluated and some of the major financial appraisal techniques are discussed below.

The Net Present Value Method discounts the cash flow (total revenue minus total costs) for each future time period (usually a year) back to the present using a suitable discount rate. If the Net Present Value is positive then the project is considered worthwhile and if a range of possible projects is being considered

Figure II[I]. The Relationship between the level of investment and total revenue.

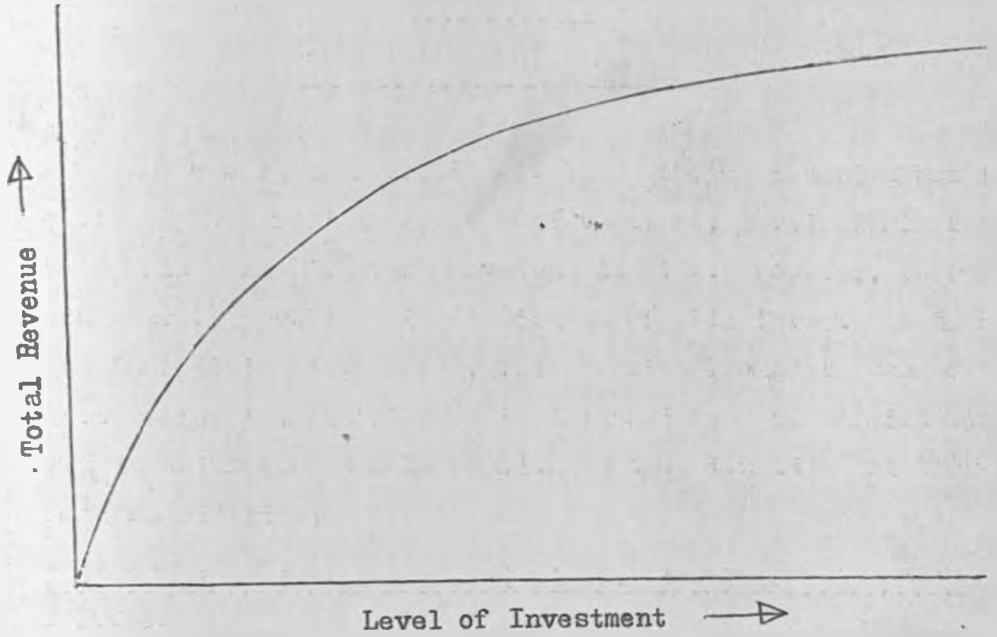
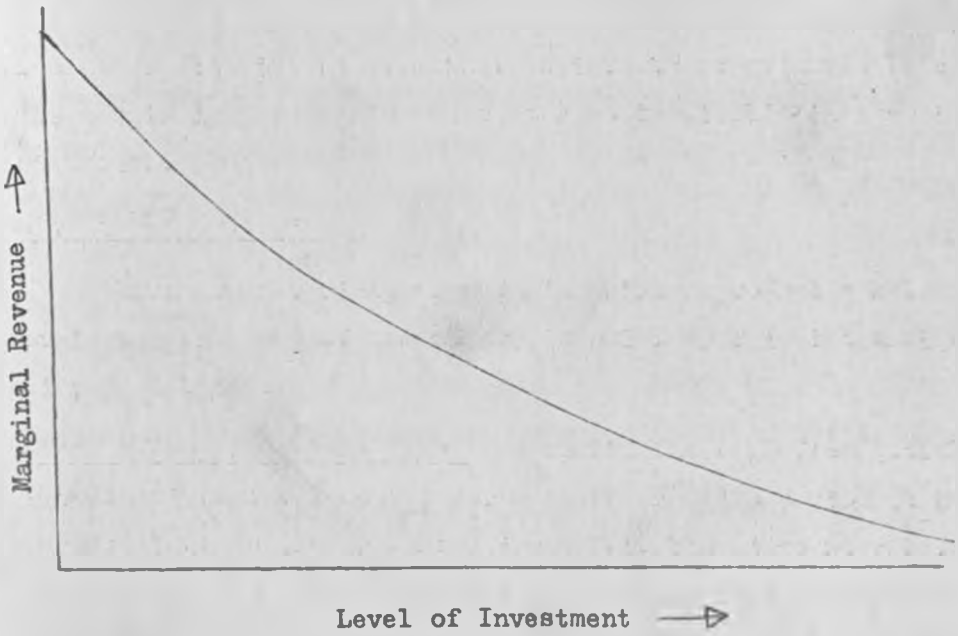


Figure II[II]. The Relationship between the level of investment and marginal revenue.



they can be ranked according to the size of their Net Present Value. However, there are problems in determining the 'correct' discount rate when at any one time there may be a range of differing borrowing and lending rates available. It is important to carefully select the discount rate since too high a rate may show a useful project not to be worthwhile and too low a rate may lead to the adoption of a scheme which is not worthwhile.

The Internal Rate of Return is the discount rate when the net present value equals zero. Providing money can be borrowed at less than the internal rate of return then the project is worthwhile. This method is unreliable for mutually exclusive schemes since the scheme with the highest internal rate of return is not necessarily the better as the other scheme may have a higher net present value at lower rates of return. Also, in schemes which involve some reinvestment at their termination this method may give two answers.

Pay Back Period assesses projects by determining how long they will take to 'pay back' the original capital outlay. This method is unsatisfactory because it does not take account of cash flows after the pay back period and ignores the timing of the cash flows within the pay back period.

Rate of Return. In fact there are many different ways of calculating the rate of return to capital. One of the most commonly used rates of return is the average income divided by the cost of the asset expressed as a percentage. Because it is possible to calculate the rate of return in a variety of ways there is a range of differing answers. For ranking projects, misleading results can be obtained if care is not taken to ensure the same method of calculating rate of return has been used for all projects concerned.

In the choice of an investment appraisal technique it is desirable to choose a method which can take account of the costs and benefits which occur, over time, as a result of the investment. These benefits and costs should then be discounted to give the present day net cost or benefit. However, the answer given by any appraisal technique is only as good as the data fed into it and where the data is sparse or inaccurate it is appropriate to choose a simple technique. While a simple technique may not give a satisfactory answer in a developed situation where all the data needed to apply a sophisticated method is not only available but accurate in an underdeveloped situation the constraints are likely to be such that the application of a simple technique is the best that can be done.

An example of a simple criteria is the marginal return investment criteria where the change in the annual net revenue is balanced against the investment cost expressed as the annual interest payable on the capital investment. In other words an investment is worthwhile if

$$DR^{11} \text{ is greater than or equal to } I_{r_1}$$

The main disadvantage of this criteria is that it ignores time in two ways. Firstly, it is unable to discount future costs and benefits and secondly it assumes that the resulting change in net revenue is instantaneous (i.e. within the assumed accounting period of one year). Since this technique is based on the change in net revenue is an approach which is more suitable for the rancher than the national economist who is also concerned with social and extra-ranch costs and benefits. The advantage of this technique is that it is simple and requires very little data.

In a situation such as the ranching activity in Kajiado District where data is often either not available or inaccurate it is only possible to meaningfully apply simple investment techniques. In order to demonstrate the use of a simple technique in such a situation some examples using the marginal investment criteria have been worked below using data developed earlier in this Chapter.

It is not being suggested that this is the sole appropriate method. On the contrary, when applying simple techniques it is very easy to obtain misleading results and it is therefore highly desirable that answers should be cross-checked by applying other appropriate appraisal techniques.

C The Application of the Marginal Return Investment Criteria

Applying the marginal return concept to the formulae in Section II of this chapter they can be rewritten as follows:-

$$D R_s = n (P_s + D P_s) D o + o n P_s$$

$$D R_c = (f D h + h D f) (P_c + D P_c) n + f h n D P_c$$

$$D R_{s+c} = (P_s + D P_s) n D o + o n D P_s + (f D h + h D f) (P_c + D P_c) n + f h n D P_c$$

$$D R_m = (b D m + m D f) (P_m + D P_m) n + m f n D P_m$$

$$D r = D R_s + D R_c + D R_m$$

$$D R^{11}_{s+c} = (P_s + D P_s) n D o + o n D P_s + (f D h + h D f) (P_c + D P_c) n + f h n D P_c - (L + D L) D (n) - n D L - (V + D V) D (n) - n D V - Ir_1$$

$$D R^{11} = (P_s + D P_s)\, n\, D\, s + o\, n\, D\, P_s$$
$$+ (f\, D\, h + h\, D\, f)\, (P_c + D P_c)\, n + f\, h\, n\, D\, P_c$$
$$+ (b\, D\, m + m\, D\, f)\, (P_m + D P_m)\, n + m\, f\, n\, D\, P_m$$
$$- (L + D L)\, D\, (n) - n\, D\, L - (V + D V)\, D\, (n)$$
$$- n\, D\, V - Ir_1$$

(the symbol 'D' is used to denote the change in the variable it precedes)

In Section I of this Chapter the percentage of animals available for sale (o) and the percentage of breeding females (f) were defined and can be expressed as follows:-

$$o = \text{function of } (c,k,p,a,h,j,e)$$

$$f = \text{function of } (c,k,p,a,h,j,e)$$

Using Table II^{III} the following examples show how the marginal criteria can be applied. Suppose that for a given situation, combination 4 gives the appropriate set of values of the variables.

Let us assume that there is a potential investment project which will increase the fraction of females calving per annum from 0.67 to 0.75 (combination 14) without influencing any of the other variables or costs or prices (e.g. investing in more fertile bulls). From the tables -

$$D R^{11}_{4\to 2} = 870 - 745.7 \text{ /-}$$
$$= 124.3 \text{ /-}$$

$$D R^{11} = 7110 - 6801.9 \text{ /-}$$
$$= 308.1 \text{ /-}$$

if I = 4000/- per 100 animals

and $r_1 = \frac{7.5}{100}$

then Ir = 7.5 + 100 x 4000/-

= 300/-

Applying the criteria D R^{11} greater than Ir_1 or equal to

D R^{11}_{n+c} is less than Ir_1

Therefore investment not undertaken

D R^{11} is greater than Ir_1

Therefore investment is undertaken.

Here we have an example of the different answers that would be given depending on whether or not the value of milk production is included. However, it must be remembered that the change in R^{11}_m does not enter the cash flow unless the investment also increases milk production beyond subsistence needs and the surplus can be sold adding to the cash flow. Therefore, if this investment was undertaken a negative cash flow would arise since the change in the revenue from the sale of cull and slaughter stock net of variable and labour costs is less than the interest payable on the capital invested unless revenue from surplus milk sales was greater than this deficit.

Secondly, consider an investment which will influence favourably all the variables without any change in costs or prices e.g. installation of more watering points. Thus the situation can be assumed to change from combination 4 to 74.

From the tables

D R^{11}_{n+c} = 1907.5 - 745.7/-

= 1161.8/-

D R^{11} = 7147.5 - 6801.9/-

= 345.6

If I = 4000/-

and r_1 = 7.5 ÷ 100

then Ir_1 = 7.5 ÷ 100 x 4000/- = 300/-

Therefore applying the criteria

D R^{11} greater than or equal to I_r

then whether or not the value of milk production was included the investment would still be worthwhile.

On the other hand if

$I = 5000/-$

and $r_1 = 7.5 \div 100$

then $I_r = 7.5 \div 100 \times 5000/- = 375/-$

Hence the investment would only appear worthwhile if the value of milk production was excluded.

The above examples show how this particular investment criteria can be applied to investment problems in Kajiado District's cattle ranching activities. However, this assumes that a limitless amount of capital is available at a fixed rate of interest. The next part therefore is concerned with investment patterns when the availability of capital is limited.

D Investment Patterns

The concept of determining investment patterns can most easily be demonstrated by working a general example.

Let us assume that there are three independent but not mutually exclusive investment possibilities, U, V and W. For the purpose of this analysis suppose that investment in each of these projects can be carried out in small steps such that the marginal revenue curve can be drawn as a continuous line. For example one such investment might be the purchase of improved breeding animals.

In choosing which project to undertake and the level of investment the following criteria would be applied.

Firstly, invest in project which gives greatest marginal return.

Secondly, invest in project for which marginal rate of return falls least relative to a given increase in capital investment.

Thirdly, continue investing until all available capital is utilised or the marginal return is equal to the interest payable on the marginal investment, whichever occurs first.

Suppose that the situation for investments U, V and W was as shown in Figure II[III] then applying the above criteria the investment would be:

1. OD in U
2. OD in V) concurrently in proportion to
   DE in U) slope of the curve
3. DF in V) concurrently in proportion to
   EG in U) slope of the curve
4. GH in W) concurrently in proportion to
   FI in V) slope of the curve
   GJ in U)

Investment would proceed in this order until either the total money available for investment had been used up. i.e.

$$I_T = I_U + I_V + I_W$$

where I_T is total capital available

I_U is investment in U

I_V is investment in V

I_W is investment in W

or until the marginal returns from each investment were equal to each other and the interest payable on that marginal investment i.e.

Figure II^{III} and II^{IV}. The Relationship between the Marginal Rate of Return and the Level of Investment in Given Projects.

Figure II^{III}.

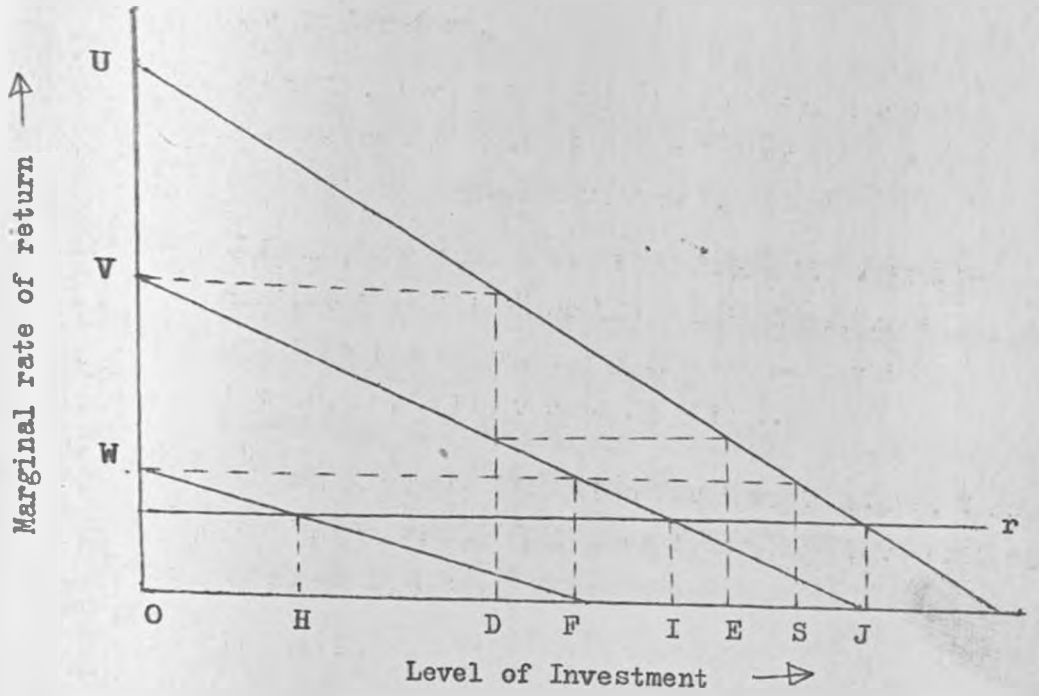
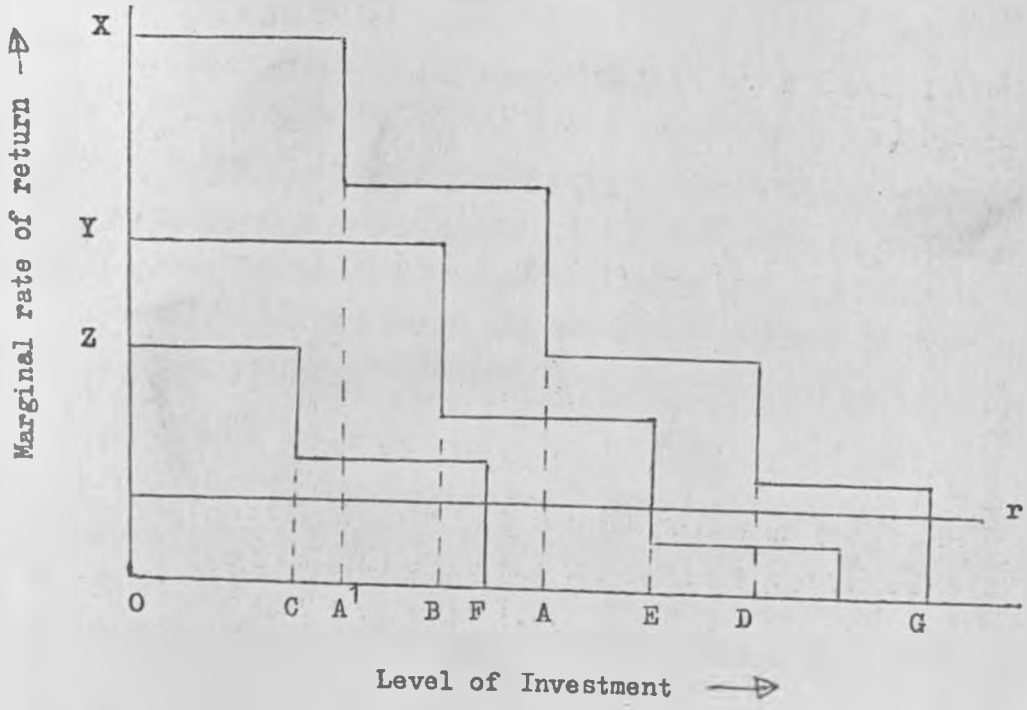


Figure II^{IV}.



$$MR_u = MR_v = MR_w = r$$

where MR_u is marginal rate of return from U

MR_v is marginal rate of return from V

MR_w is marginal rate of return from W

r is rate of interest payable on capital

The limit of investment would be whichever of these situations is reached first.

In practice investment opportunities in the ranching activity is likely to be in sizable amounts e.g. investment in cattle dips. Therefore, consider three investment opportunities X, Y and Z which take the form shown in Figure II[IV].

Applying the above criteria the investment pattern would be:

1. OA in X
2. OB in Y
3. OC in Z
4. AD in X
5. BE in Y
6. CF in Z
7. DG in X

Again investment would continue up to the point where the total finance available had been totally used up (i.e. $I_T = I_X + I_Y + I_Z$) or where the marginal returns from all three investments are equal to each other and the rate of interest payable on the marginal capital investment (i.e. $MR_X = MR_Y = MR_Z = r$).

CONCLUSION

The formulae in Section II have been developed so that revenues at either ranch or district level can be calculated by using the relevant estimate of the cattle population. Likewise the investment criteria can be used at ranch or district level.

However, the investment appraisal technique which was demonstrated is only concerned with returns to the rancher or ranchers and for national planning purposes it is necessary to employ other techniques which take account of social and off-ranch costs and benefits. The marginal return technique was demonstrated because of its simplicity of application given limited data but problems arise because it is not able to take account of time.

The numerical examples which have been worked illuminate the effect of either including or excluding the value of subsistence milk production when appraising an investment opportunity. Depending on whether the value of subsistence milk is included or excluded, different answers to management and investment problems are obtained. Hence, there is an urgent need to research into the problem of if and how subsistence milk production should be evaluated.

TABLE XI[I]: POTENTIAL INCREASE IN HERD FOR GIVEN VALUES OF CALVING INTERVAL, CALF SURVIVAL AND PERCENTAGE OF BREEDING FEMALES IN THE HERD

Increase in herd (i) = c k f

Calf survival		100% (k=1)			95% (k=0.95)			90% (k=0.9)			80% (k=0.8)		
Calving interval		12 mths (c=1)	18 mths (c=0.67)	24 mths (c=0.5)	12 mths	18 mths	24 mths	12 mths	18 mths	24 mths	12 mths	18 mths	24 mths
Breeding females as % total herd (f)	25%	25%	16.7%	12.5%	23.8%	15.9%	11.9%	22.5%	15.1%	11.3%	20%	13.4%	10%
	30%	30%	20.1%	15%	28.5%	20%	14.3%	27%	18.1%	13.5%	24%	16.1%	12%
	40%	40%	26.8%	20%	38%	25.5%	19%	36%	24.1%	18%	32%	21.4%	16%
	45%	45%	30.2%	22.5%	42.8%	28.6%	21.4%	40.5%	27.1%	20.3%	36%	24.1%	18%
	50%	50%	33.5%	25%	47.5%	31.8%	23.8%	45%	30.2%	22.5%	40%	26.8%	20%
	60%	60%	40.2%	30%	57%	38.2%	28.5%	54%	36.2%	27%	48%	32.2%	24%

TABLE II[II]: BREEDING FEMALES AS A PERCENTAGE TOTAL HERD AND PERCENTAGE HERD AVAILABLE FOR SALE FOR DIFFERING COMBINATIONS OF VALUES OF VARIABLES AFFECTING HERD STRUCTURE

	c	k	p	a	h	j	e	f 1/	o 2/
	Fraction of breeding females calving in any given year.	Survival rate of calves	Age first calf produced	Age of sale	Replacement rate p.a. of breeding females	Bull-breeding female ratio	Survival rate of immatures	Breeding females as % total herd	% herd available for sale
1)	0.67	0.85	3	1	0.14	0.1	0.95	40.1	16.1
2)	0.67	0.85	3	2	0.14	0.1	0.95	35.0	13.1
3)	0.67	0.85	3	3	0.14	0.1	0.95	31.1	10.8
4)	0.67	0.85	3	4	0.14	0.1	0.95	28.3	9.2
5)	0.67	0.85	3	5	0.14	0.1	0.95	26.1	7.8
6)	0.5	0.85	3	1	0.14	0.1	0.95	45.3	11.9
7)	0.5	0.85	3	2	0.14	0.1	0.95	40.8	9.9
8)	0.5	0.85	3	3	0.14	0.1	0.95	37.4	8.4
9)	0.5	0.85	3	4	0.14	0.1	0.95	34.7	7.1
10)	0.5	0.85	3	5	0.14	0.1	0.95	32.6	6.1
11)	0.75	0.85	3	1	0.14	0.1	0.95	38.1	17.7
12)	0.75	0.85	3	2	0.14	0.1	0.95	32.7	14.2
13)	0.75	0.85	3	3	0.14	0.1	0.95	28.9	11.7
14)	0.75	0.85	3	4	0.14	0.1	0.95	26.0	9.9
15)	0.75	0.85	3	5	0.14	0.1	0.95	23.8	8.4
16)	0.67	0.95	3	1	0.14	0.1	0.95	38.2	17.7
17)	0.67	0.95	3	2	0.14	0.1	0.95	32.7	14.2
18)	0.67	0.95	3	3	0.14	0.1	0.95	28.9	11.8
19)	0.67	0.95	3	4	0.14	0.1	0.95	26.0	9.9
20)	0.67	0.95	3	5	0.14	0.1	0.95	23.9	8.4
21)	0.67	0.9	3	1	0.14	0.1	0.95	39.1	16.9
22)	0.67	0.9	3	2	0.14	0.1	0.95	33.8	13.7
23)	0.67	0.9	3	3	0.14	0.1	0.95	30.0	11.3
24)	0.67	0.9	3	4	0.14	0.1	0.95	27.1	9.5
25)	0.67	0.9	3	5	0.14	0.1	0.95	24.9	8.1

TABLE II[II] (continued)

	c	k	p	a	h
26	0.67	0.8	3	1	0.14
27	0.67	0.8	3	2	0.14
28	0.67	0.8	3	3	0.14
29	0.67	0.8	3	4	0.14
30	0.67	0.8	3	5	0.14
31	0.67	0.85	2	1	0.14
32	0.67	0.85	2	2	0.14
33	0.67	0.85	2	3	0.14
34	0.67	0.85	2	4	0.14
35	0.67	0.85	2	5	0.14
36	0.67	0.85	4	1	0.14
37	0.67	0.85	4	2	0.14
38	0.67	0.85	4	3	0.14
39	0.67	0.85	4	4	0.14
40	0.67	0.85	4	5	0.14
41	0.67	0.85	3	1	0.12
42	0.67	0.85	3	2	0.12
43	0.67	0.85	3	3	0.12
44	0.67	0.85	3	4	0.12
45	0.67	0.85	3	5	0.12
46	0.67	0.85	3	1	0.17
47	0.67	0.85	3	2	0.17
48	0.67	0.85	3	3	0.17
49	0.67	0.85	3	4	0.17
50	0.67	0.85	3	5	0.17
51	0.67	0.85	3	1	0.14
52	0.67	0.85	3	2	0.14
53	0.67	0.85	3	3	0.14
54	0.67	0.85	3	4	0.14
55	0.67	0.85	3	5	0.14
56	0.67	0.85	3	1	0.14
57	0.67	0.85	3	2	0.14

j	o	£	o
0.1	0.95	41.2	15.2
0.1	0.95	36.1	12.4
0.1	0.95	32.4	10.3
0.1	0.95	29.5	8.8
0.1	0.95	27.3	7.5
0.1	0.95	42.5	17.1
0.1	0.95	36.7	13.7
0.1	0.95	32.5	11.3
0.1	0.95	29.4	9.5
0.1	0.95	27.0	8.1
0.1	0.95	38.0	15.2
0.1	0.95	33.3	12.4
0.1	0.95	29.8	10.4
0.1	0.95	27.2	8.8
0.1	0.95	25.1	7.6
0.1	0.95	40.8	17.2
0.1	0.95	35.2	13.8
0.1	0.95	31.1	11.5
0.1	0.95	28.1	9.7
0.1	0.95	25.8	8.3
0.1	0.95	39.2	14.5
0.1	0.95	34.5	11.9
0.1	0.95	31.1	9.9
0.1	0.95	28.5	8.4
0.1	0.95	26.5	7.2
0.1	0.95	38.6	15.5
0.2	0.95	33.7	12.6
0.2	0.95	30.2	10.5
0.2	0.95	27.5	8.9
0.2	0.95	25.4	7.6
0.2	0.95	40.6	16.3
0.07	0.95	35.3	13.2
0.07	0.95		

TABLE XI[II] (continued)

	c	k	p	a	h	j	e	f	o
58)	0.67	0.85	3	3	0.14	0.07	0.95	31.4	10.9
59)	0.67	0.85	3	4	0.14	0.07	0.95	28.5	9.2
60)	0.67	0.85	3	5	0.14	0.07	0.95	26.3	7.9
61)	0.67	0.85	3	1	0.14	0.1	0.98	39.9	16.7
62)	0.67	0.85	3	2	0.14	0.1	0.98	34.3	14.0
63)	0.67	0.85	3	3	0.14	0.1	0.98	30.2	12.0
64)	0.67	0.85	3	4	0.14	0.1	0.98	27.1	10.4
65)	0.67	0.85	3	5	0.14	0.1	0.98	24.6	9.2
66)	0.67	0.85	3	1	0.14	0.1	0.9	40.6	15.1
67)	0.67	0.85	3	2	0.14	0.1	0.9	35.9	11.5
68)	0.67	0.85	3	3	0.14	0.1	0.9	32.7	9.0
69)	0.67	0.85	3	4	0.14	0.1	0.9	30.4	7.1
70)	0.67	0.85	3	5	0.14	0.1	0.9	28.7	5.6
71)	0.75	0.95	2	1	0.12	0.07	0.98	34.5	22.2
72)	0.75	0.95	2	2	0.12	0.07	0.98	31.6	17.8
73)	0.75	0.95	2	3	0.12	0.07	0.98	26.9	14.8
74)	0.75	0.95	2	4	0.12	0.07	0.98	23.5	12.6
75)	0.75	0.95	2	5	0.12	0.07	0.98	20.9	11.0
76)	1	1	2	1	0.1	0.05	1	31.7	28.6
77)	1	1	2	2	0.1	0.05	1	24.7	22.2
78)	1	1	2	3	0.1	0.05	1	20.2	18.2
79)	1	1	2	4	0.1	0.05	1	17.1	15.4
80)	1	1	2	5	0.1	0.05	1	14.8	13.3

1/ $$f = \frac{100}{\left[c\,k\,(1 + c + \ldots + c^{a}) + (p-a)\,h + 1 + j \right]}$$

2/ $$o = \frac{(ckc^{a} - h)\,100}{\left[c\,k\,(1 + c + \ldots + c^{a}) + (p-a)\,h + 1 + j \right]}$$

Discrepancies are due to rounding.

TABLE II[III]: POTENTIAL REVENUES BASED ON

	$R_s = P_s$ on (shs)	$R_c = P_c$ fhn (shs)	$R_{s+c} = P_s$ on + P_c bhn (shs)	$R^1_{s+c} = P_s$ on + P_c fhn − Vn (shs)	$R^{11}_{s+c} = P_s$ on + P_c fhn − $\{(V+L)n$ (shs)
1.	1207.5	2110.5	3318	318	− 642
2.	2489	1832.2	4321.2	1321.2	361.2
3.	2970	1632.7	4602.7	1602.7	642.7
4.	3220	1485.7	4705.7	1705.7	745.7
5.	3042	1365	4407	1407	447
6.	892.5	2378.2	3270.7	270	− 690
7.	1881	2142	4023	1023	63
8.	2310	1963.5	4273.5	1273.5	313.5
9.	2485	1821.7	4306.7	1306.7	346.7
10.	2379	1711.5	4090.5	1090.5	130.5
11.	1327.5	2000.2	3327.7	327.7	− 632.3
12.	2698	1716.7	4414.7	1414.7	454.7
13.	3217.5	1517.2	4734.7	1734.7	774.7
14.	3465	1365	4830	1830	870
15.	3276	1249.5	4525 5	1525.5	565.5
16.	1327.5	2005.5	3333	333	− 627
17.	2698	1716.7	4414.7	1414.7	454.7
18.	3245	1517.2	4762.2	1762.2	802.2
19.	3465	1365	4830	1830	870
20.	3276	1254.7	4530.7	1530.7	570.7
21.	1267.5	2052.7	3320.2	320.2	− 639.8
22.	2603	1774.5	4377.5	1377.5	417.5
23.	3107.5	1575	4682.5	1682.5	722.5
24.	3325	1422.7	4747.7	1747.7	787.7
25.	3159	1307.2	4466.2	1466.2	506.2
26.	1140	2163	3303	303	− 657
27.	2356	1895.2	4251.2	1251.2	291.2
28.	2832.5	1701	4533.5	1533.5	573.5
29.	3080	1548.7	4628.7	1628.7	668.7
30.	2925	1433.2	4358.2	1358.2	398.2

TABLE II[II] (PER HEAD OF 100 ANIMALS)

$R_m = P_m mfcn$	$R = P_m mfcn + P_o on + P_o fhn$	$R^1 = P_m mfcn + P_o on + P_o fhn - Vn$	$R^{11} = P_m mfcn + P_o on + P_o fhn - (V+L)$
(shs)	(shs)	(shs)	(shs)
8602.8	11920.8	8920.8	7960.8
7468.6	11789.8	8789.8	7829.8
6655.4	11258.1	8258.1	7298.1
6056.2	10761.9	7761.9	6801.9
5564	9971	6971	6011.0
7248	10518.7	7518.7	6558.7
6528	10551	7551	6591.0
5984	10257.5	7257.5	6297.5
5552	9858.7	6858.7	5898.7
5216	9306.5	6306.5	5346.5
9144	12471.7	9471.7	8511.7
7848	12262.7	9262.7	8302.7
6936	11670.7	8670.7	7710.7
6240	11070	8070	7110.0
5712.	10237.5	7237.5	6277.5
8174.8	11507.8	8507.8	7547.8
6997.8	11412.5	8412.5	7452.5
6184.6	10946.8	7946.8	6986.8
5564	10394	7394	6434
5114.6	9645.3	6645.3	5685.3
8367.4	11687.6	8687.6	7727.6
7233.2	11610.7	8610.7	7650.7
6420	11102.5	8102.5	7142.5
5799.4	10547.1	7547.1	6587.1
5328.6	9794.8	6794.8	5834.8
8816.8	12119.8	9199.8	8159.8
7725.4	11976.6	8976.6	8016.6
6933.6	11467.1	8467.1	7507.1
6313	10941.7	7941.7	6981.7
5842.2	10200.4	7200.4	6240.4

TABLE II[III] (continued)

	R_s	R_c	R_{s+c}	R'_{s+c}	R''_{s+c}
31.	1282.5	2231.2	3513.7	513.7	- 445.3
32.	2603	1926.7	4529.7	1529.7	569.7
33.	3107.5	1706.2	4813.7	1813.7	853.7
34.	3325	1543.5	4868.5	1868.5	908.5
35.	3159	1417.5	4576.5	1576.5	616.5
36.	1140	1995	3135	135	- 825
37.	2356	1748.2	4104.2	1104.2	144.2
38.	2860	1564.5	4424.5	1424.5	464.5
39.	3080	1428	4508	1508	548.0
40.	2964	1317.7	4281.7	1281.7	321.7
41.	1290	1836	3126	126	- 834
42.	2622	1584	4206	1206	246
43.	3162.5	1399.5	4562	1562	602
44.	3395	1264.5	4659.5	1659.5	699
45.	3237	1161	4398	1398	438
46.	1087.5	2499	3586.5	586.5	- 373.5
47.	2261	2199.4	4460.4	1460.4	500.4
48.	2722.5	1982.6	4705.1	1705.1	745.1
49.	2940	1816.9	4756.9	1756.9	796.9
50.	2808	1689.4	4497.4	1497.4	537.4
51.	1162.5	2026.5	3189	189	- 771
52.	2394.0	1769.2	4163.2	1163.2	203.2
53.	2887.5	1585.5	4478	1473	513
54.	3115.0	1443.7	4558.7	1558.7	598.7
55.	2964	1333.5	4297.5	1297.5	337.5
56.	1222.5	2131.5	3354	354	- 606
57.	2508	1853.2	4361.2	1361.2	401.2
58.	2997.5	1648.5	4646	1646	686
59.	3220	1496.2	4716.2	1716.2	756.2
60.	3081	1380.7	4461.7	1461.7	501.7
61.	1252.5	2094.7	3347.3	347.3	- 612.7
62.	2660	1800.7	4460.7	1460.7	500.7
63.	3300	1585.5	4885.5	1885.5	925.5

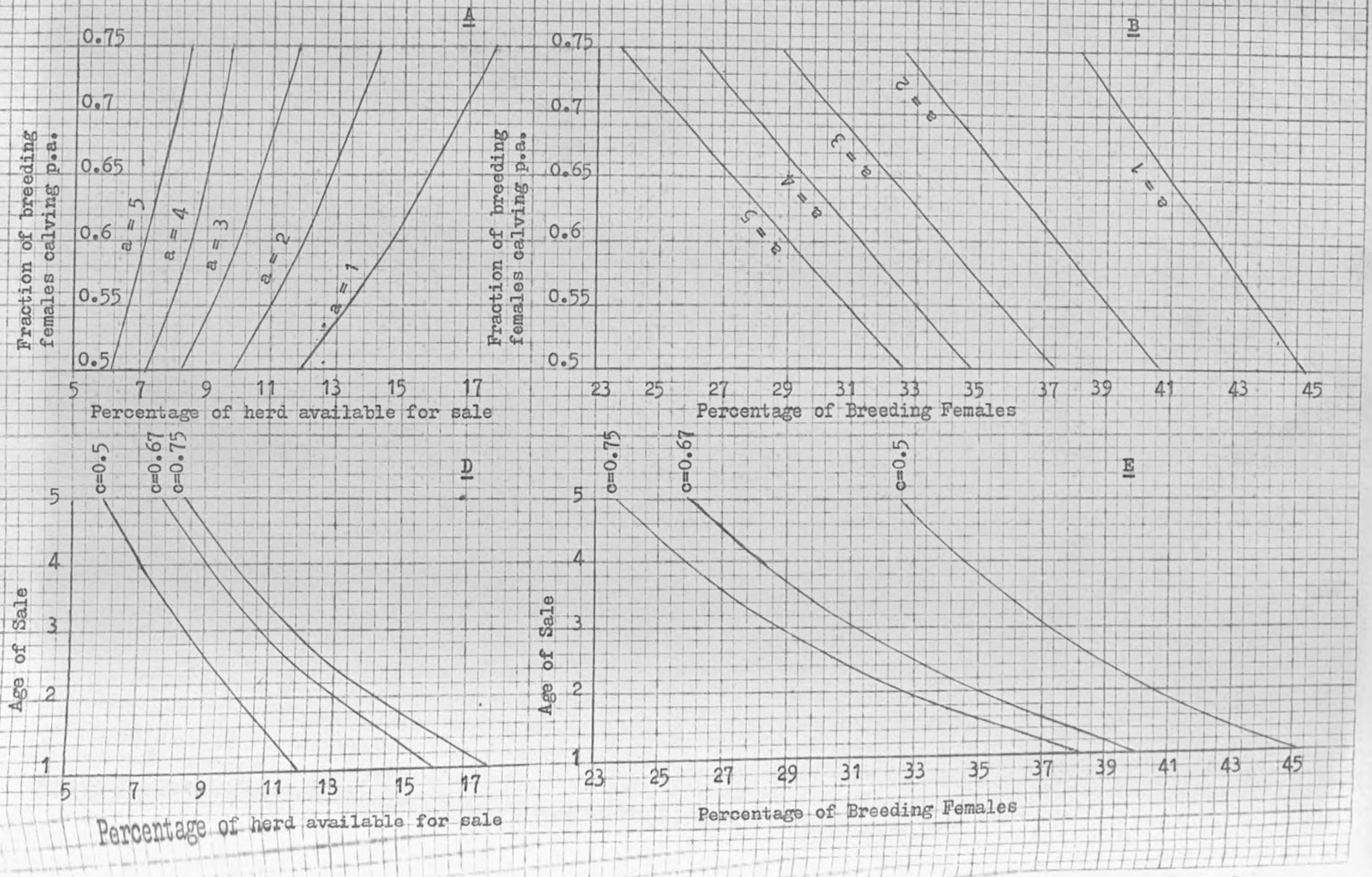
R_m	R	R^1	R^{11}
9095	12608.7	9608.7	8648.7
7853.8	12383.5	9383.5	8423.5
6955	11768.7	8768.7	7808.7
6291.6	11160.1	8160.1	7200.1
5778	10354.5	7354.5	6394.5
8132	11267	8267	7307.0
7126.2	11123.4	8230.4	7270.4
6377.2	10801.7	7801.7	6841.7
5820.8	10328.8	7328.8	6368.8
5371.4	9658.1	6653.1	5693.1
8731.2	11857.2	8857.2	7897.2
7532.8	11738.8	8738.8	7778.8
6655.4	11217.4	8217.4	7257.4
6013.4	10672.9	7672.9	6712.9
5521.2	9919.2	6919.2	5959.2
8388.8	11975.3	8935.3	7975.3
7383	11843.4	8843.4	7883.4
6655.4	11360.5	8360.5	7400.5
6099	10855.9	7855.9	6895.9
5671	10168.4	7168.4	6208.4
8260.4	11449.4	8449	7489.4
7211.8	11375	8375	7415.0
6462.8	10935.8	7935.8	6975.8
5885	10443.7	7443.7	6483.7
5435.6	9733.1	6733.1	5773.1
8688.4	12042.4	9042.4	8082.4
7554.2	11915.4	8915.4	8032.4
6719.6	11365.6	8365.6	7405.6
6099	10815.2	7815.2	6855.2
5628.2	10089.9	7089.9	6129.9
8538.6	11885.8	8885.8	7925.8
7340.2	11800.9	8800.9	7840.9
6462.8	11348.3	8348.3	7388.3

TABLE II^{III} (continued)

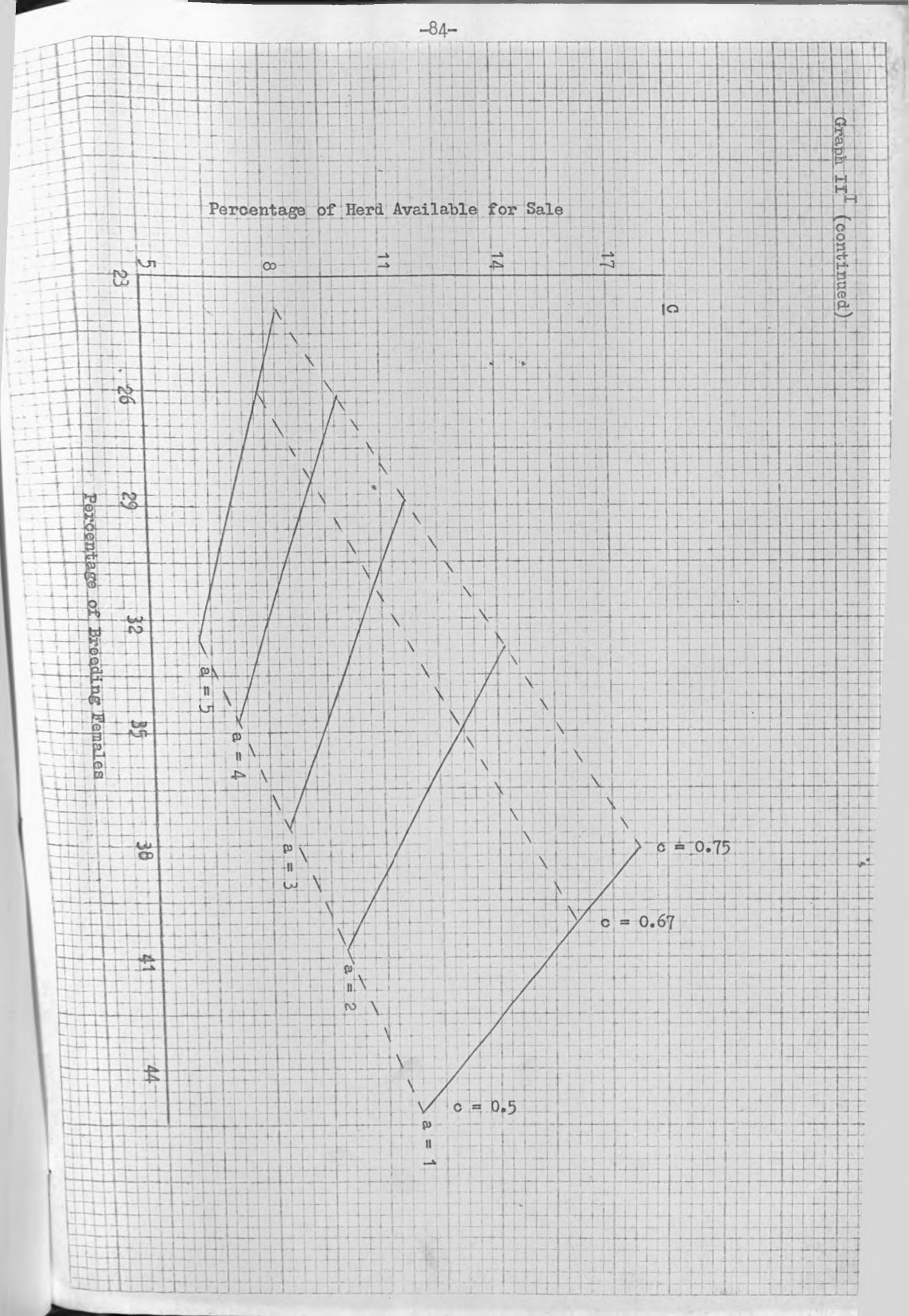
	R_s	R_c	R_{s+c}	R^1_{s+c}	R^{11}_{s+c}
64.	3640	1417.5	5057.5	2057.5	1097.5
65.	3588	1291.5	4379.5	1879.5	919.5
66.	1132.5	2131.5	3264	264	- 696
67.	2185	1884.7	4069.7	1069.7	109.7
68.	2475	1716.7	4191.7	1191.7	231.7
69.	2485	1596	4081	1081	121.0
70.	2184	1506.7	3690.7	690.7	- 269.3
71.	1665	1552.5	3217.5	217.5	- 724.5
72.	3382	1422	4804	1304	844
73.	4070	1210.5	5280.5	2280.5	1320.5
74.	4410	1057.5	5467.5	2867.5	1907.5
75.	4251	940	5191.5	2191.5	1231.5
76.	2145	1188.7	3333.7	333.7	- 626.3
77.	4218	926.2	5144.2	2144.2	1184.2
78.	5005	757.5	5762.5	2762.5	1802.5
79.	5390	641.3	6031.3	3031.3	2071.3
80.	5187	555	5742	2742	1782

R_m	R	R^1	R^{11}
5778	10835.5	7835.5	6875.5
5264.4	10143.9	7143.9	6183.9
8688.4	11952.4	8952.4	7992.4
7682.6	11752.4	8752.4	7792.4
6997.8	11189.5	8189.5	7229.5
6505.6	10586.6	7586.6	6626.6
6141.8	9832.5	6832.5	5872.5
8280	11497.5	8497.5	7537.5
7584	12388	9388	8428
6456	11736.5	8736.5	7776.5
5640	11107.5	8107.5	7147.5
5016	10207.5	7207.5	6247.5
10112.3	13446	10446	9486
7879.3	13023.5	10023.5	9063.5
6443.8	12206.3	9206.3	8246.3
5454.9	11486.2	8486.2	7526.2
4721.2	10463.2	7463.2	6503.2

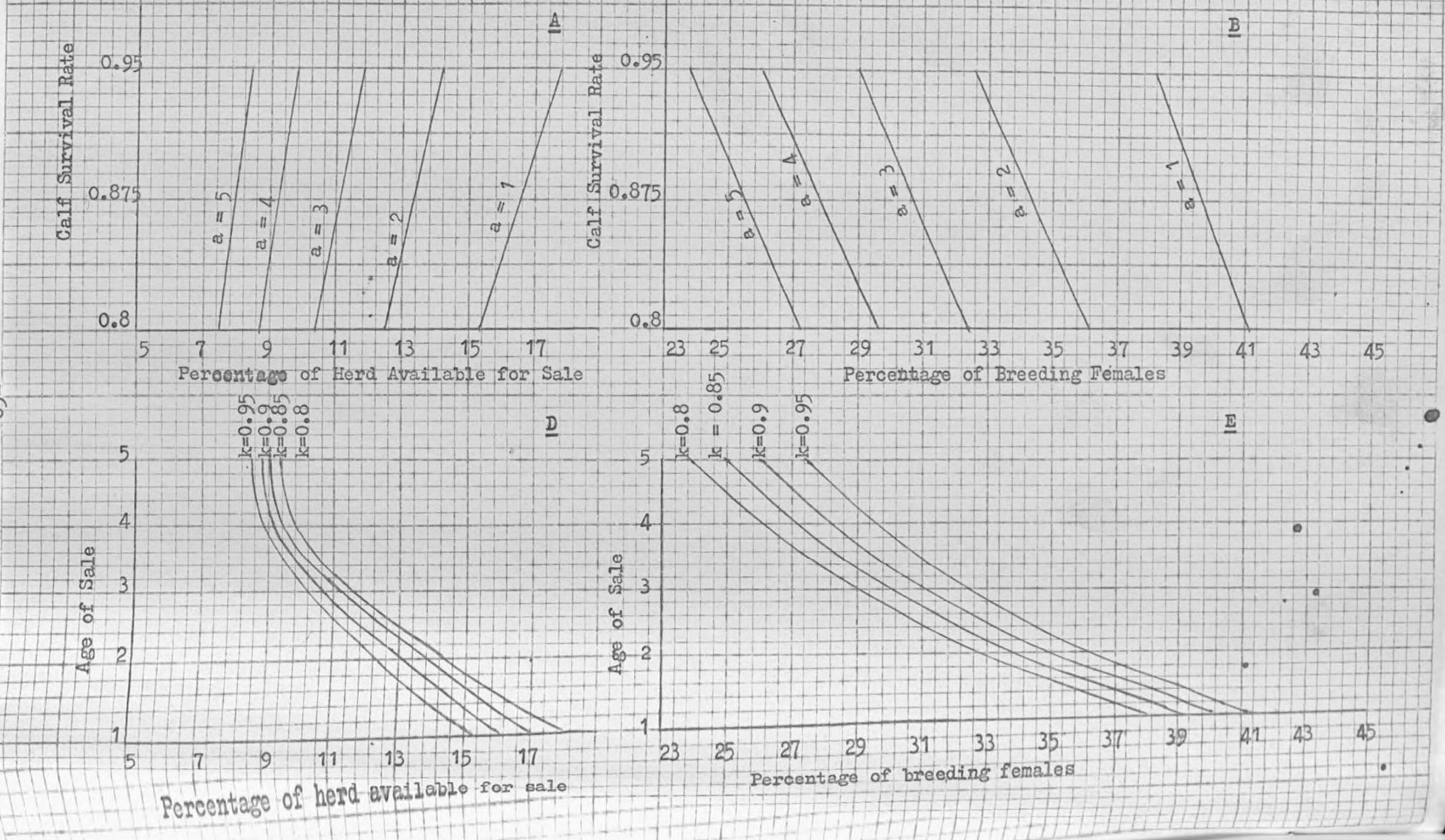
Graph II[I]. The Influence of the Fraction of the Breeding Females Calving per annum (c) on the Percentage of Breeding Females and the Percentage of the Herd Available for Sale with respect to the Age of Sale.



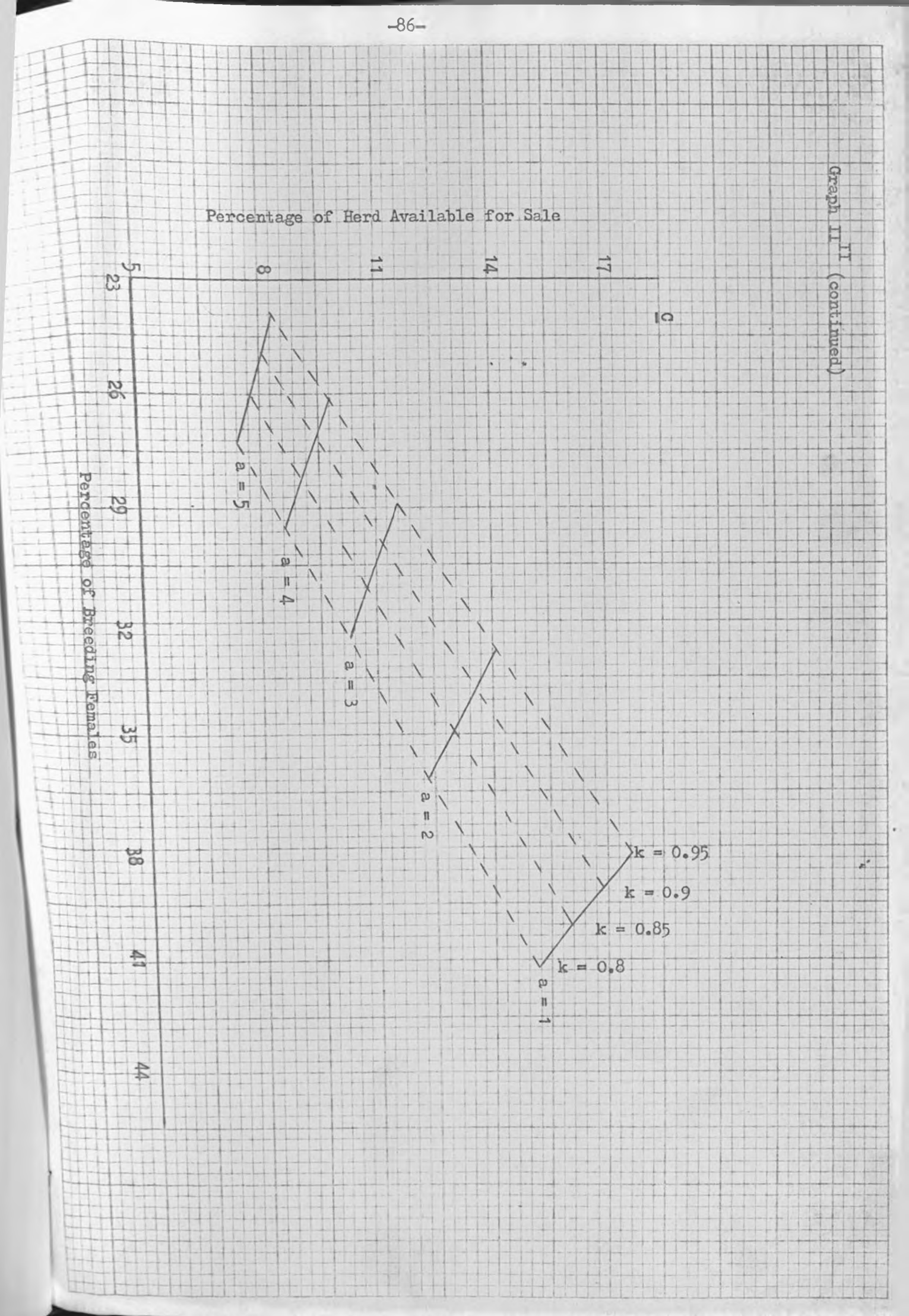
Graph III (continued)



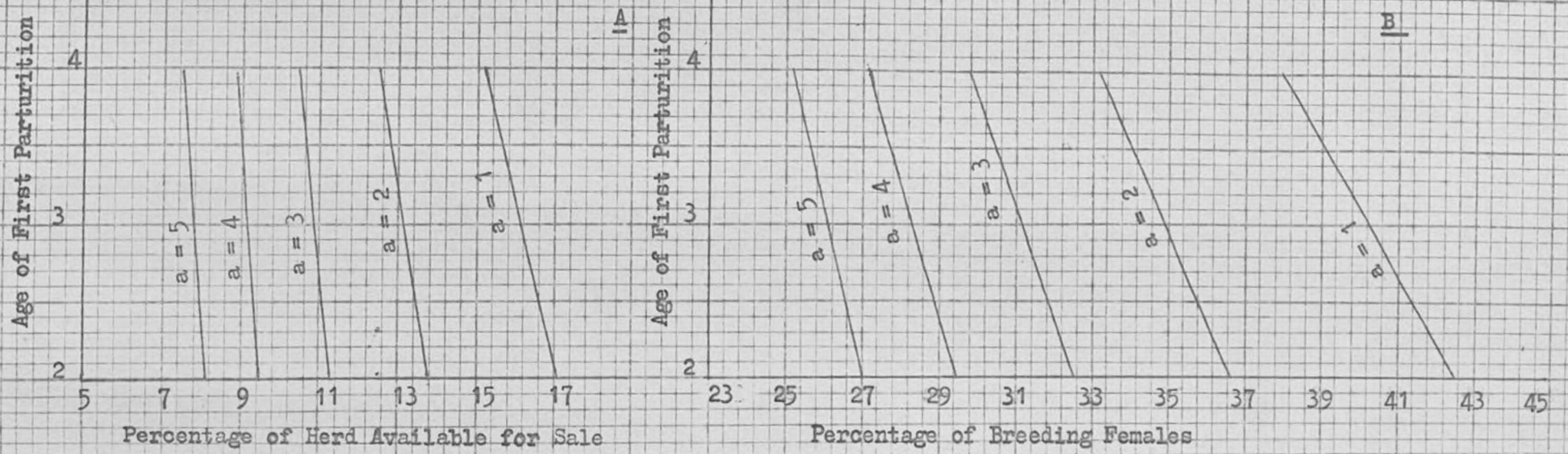
Graph II[II]. The Influence of the Fraction of the Survival Rate of Calves (k) on the Percentage of Breeding Females and the Percentage of the Herd Available for Sale with respect to the Age of Sale.

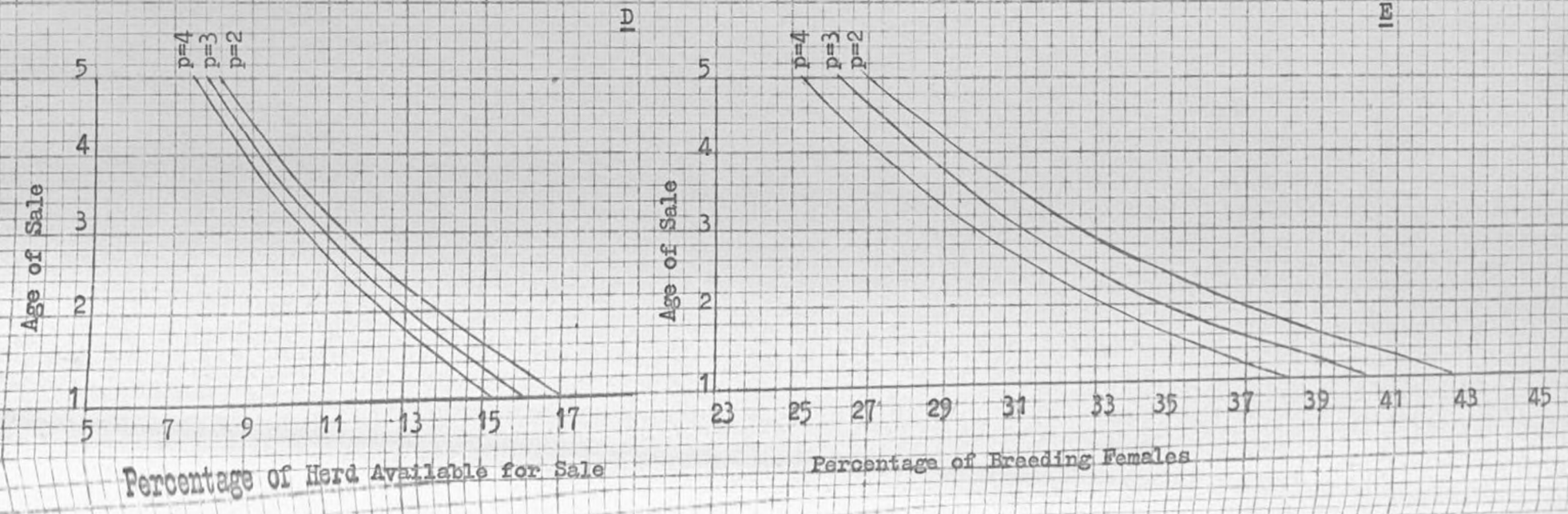


Graph II[II] (continued)

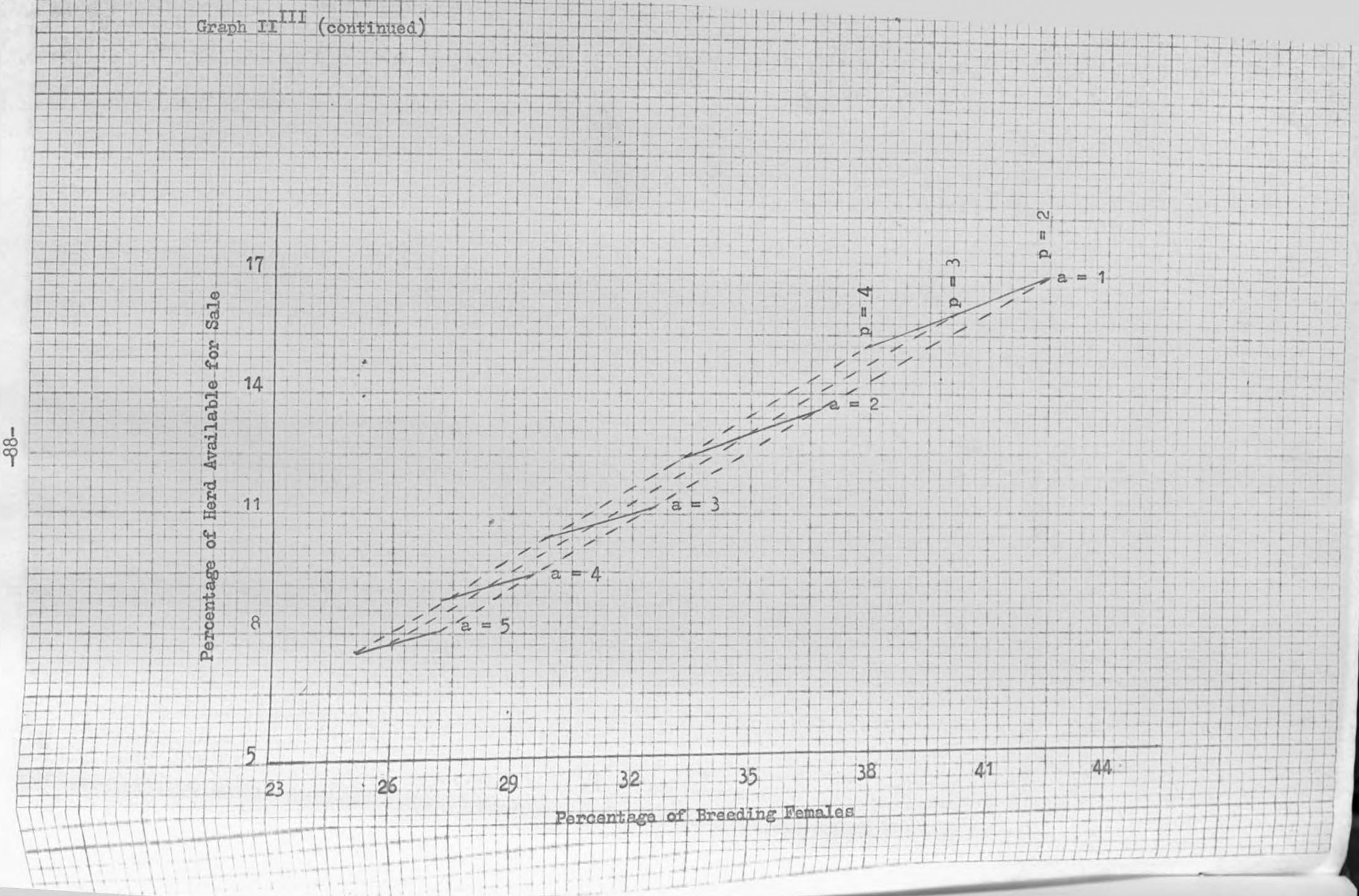


Graph II[III]. The Influence of the Fraction of the Age of First Parturition (p) on the Percentage of Breeding Females and the Percentage of the Herd Available for Sale with respect of the Age of Sale.

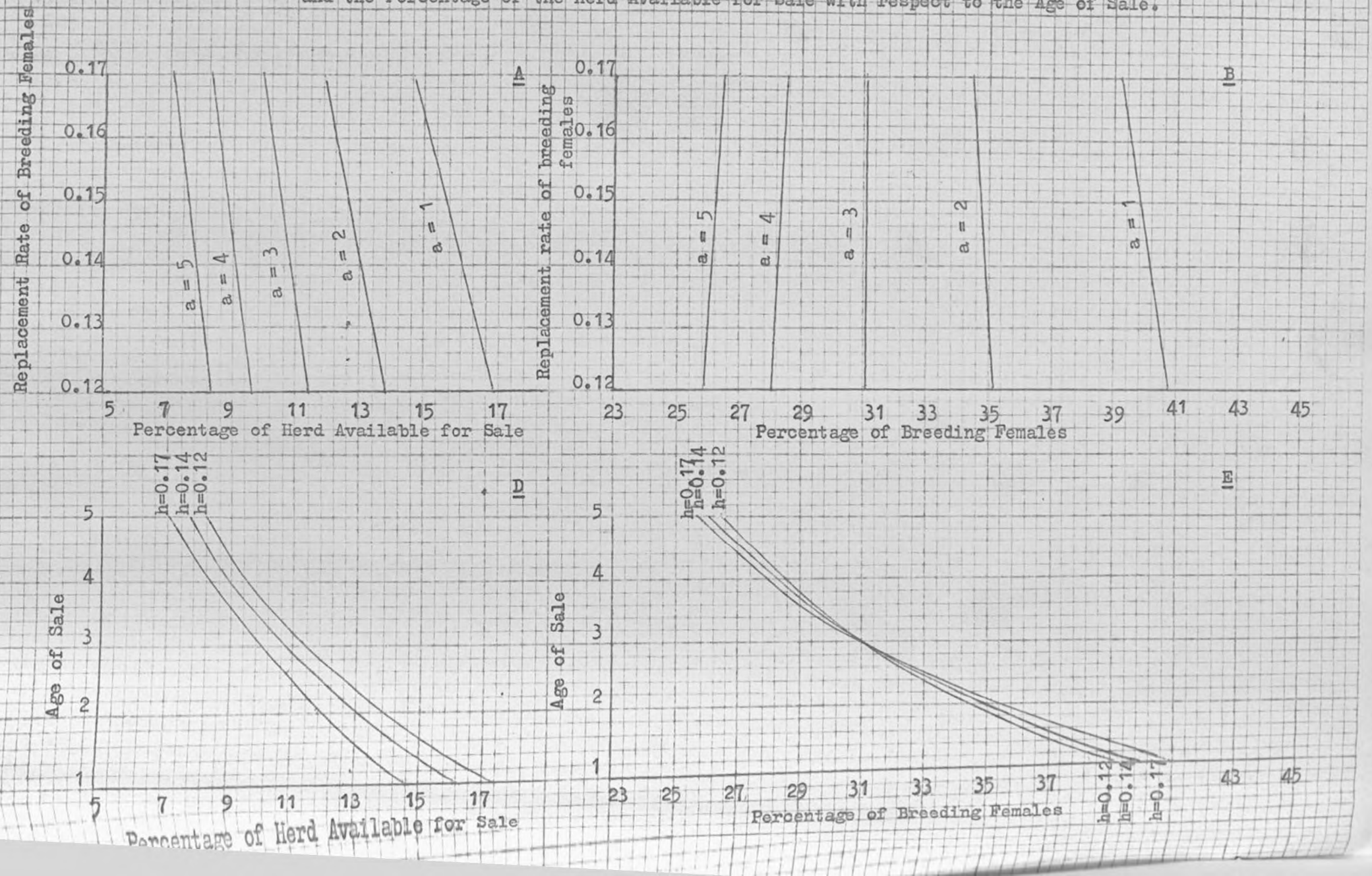




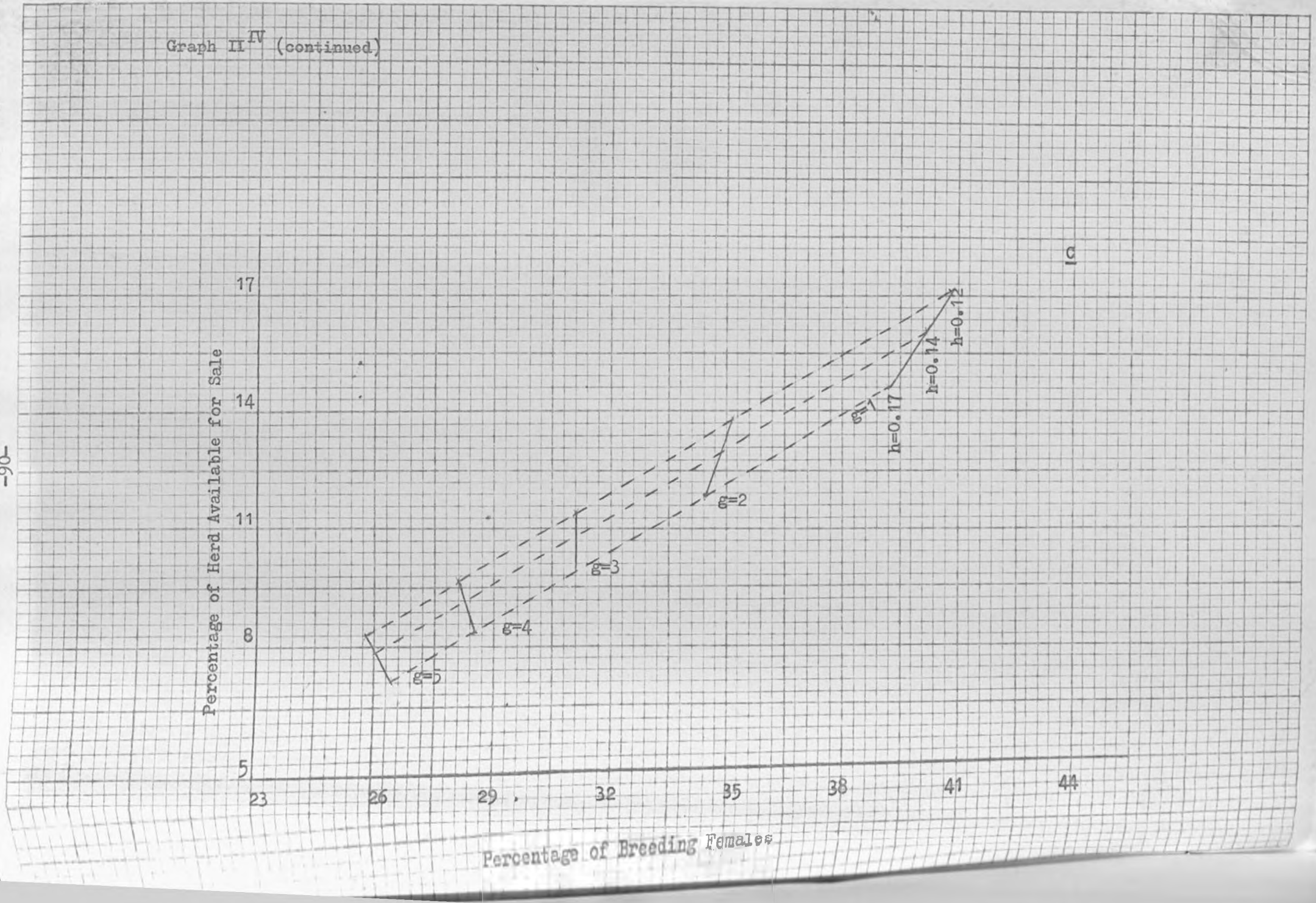
Graph II[III] (continued)



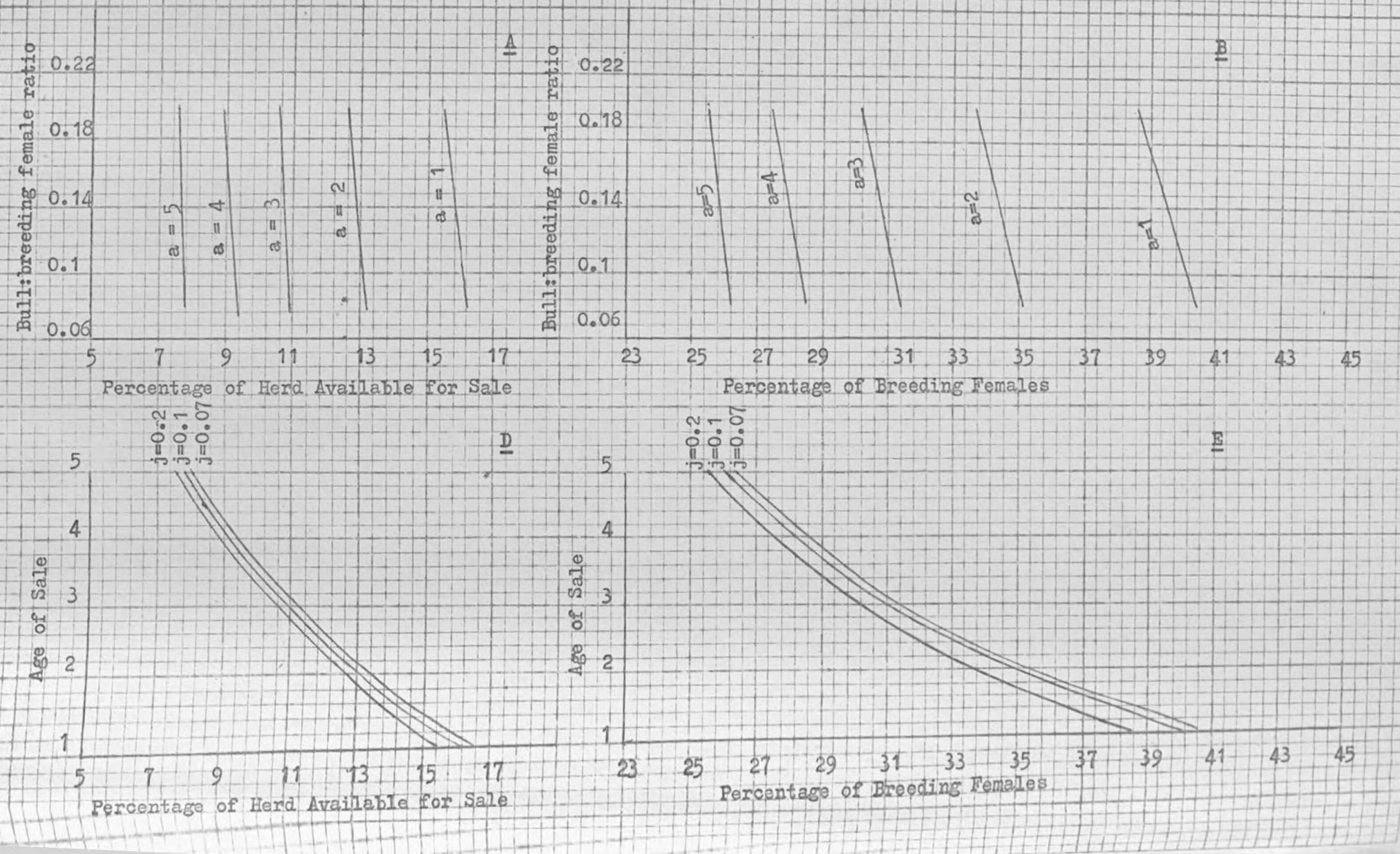
Graph II[IV]. The Influence of the Fraction of the Annual Replacement Rate of Breeding Females (h) and the Percentage of the Herd Available for Sale with respect to the Age of Sale.



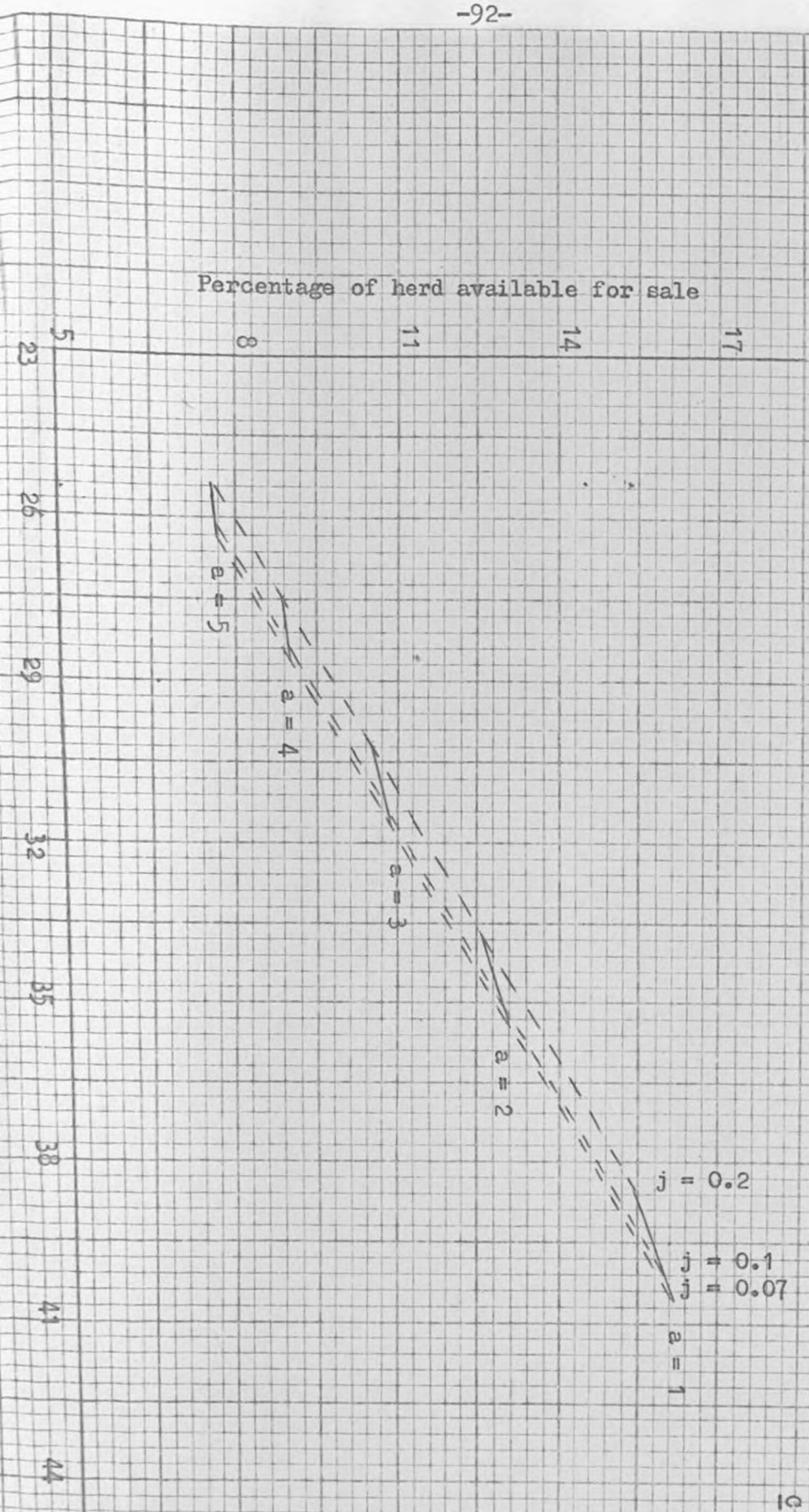
Graph II[IV] (continued)



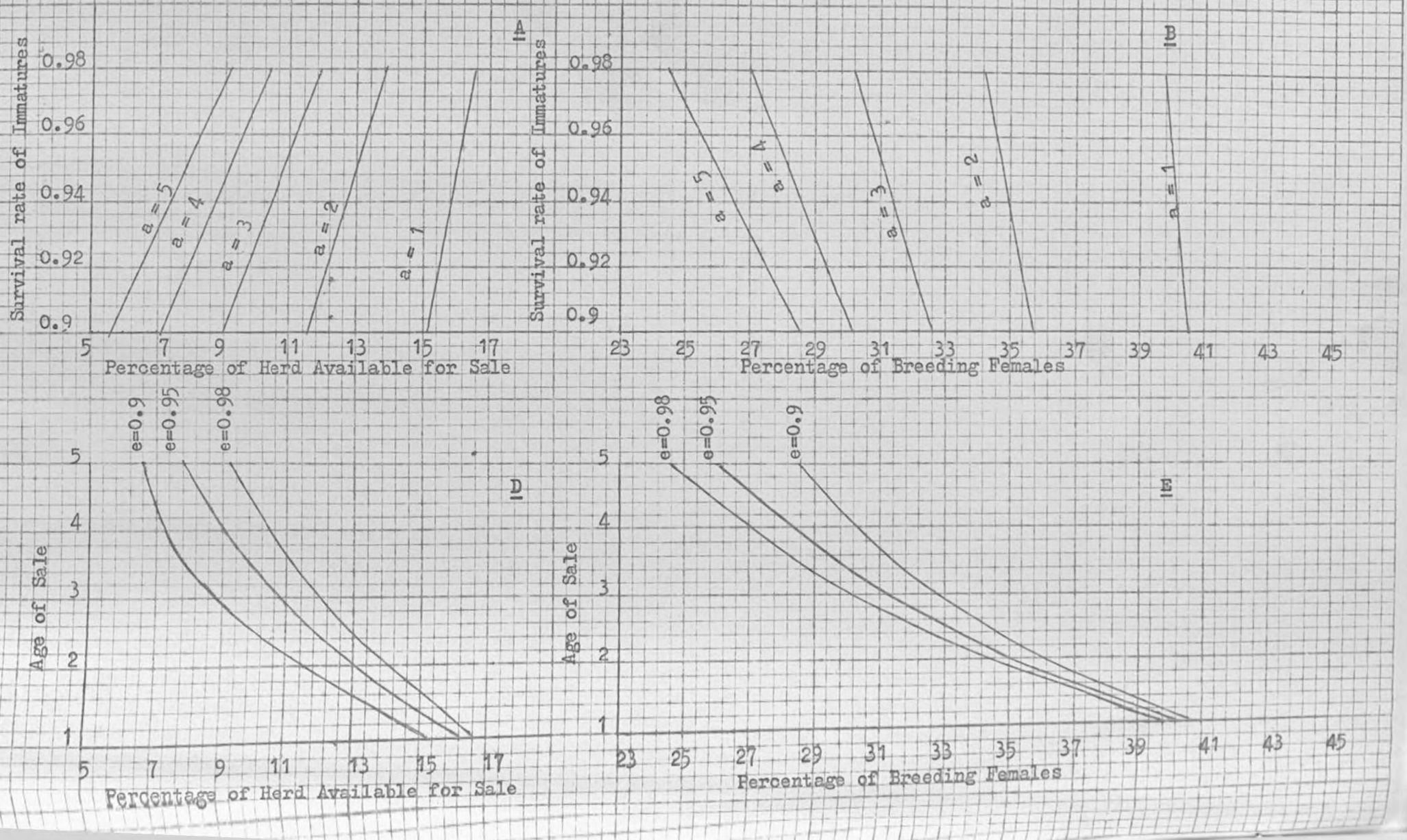
Graph II[V]. The Influence of the Fraction of the Bull:Breeding Female Ratio (j) on the Percentage of Breeding Females and the Percentage of the Herd Available for Sale with respect to the Age of Sale.



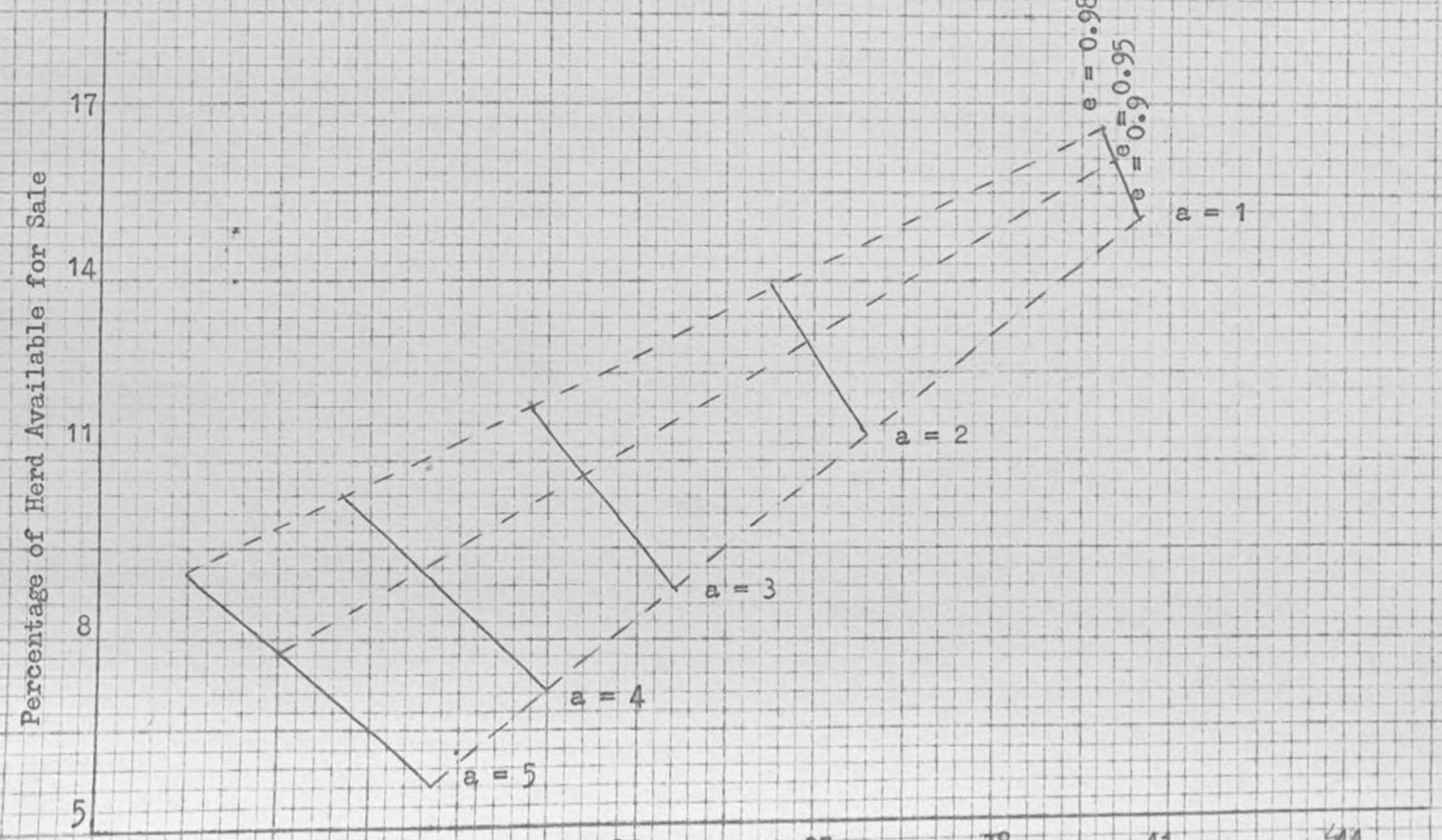
Graph IV (continued)



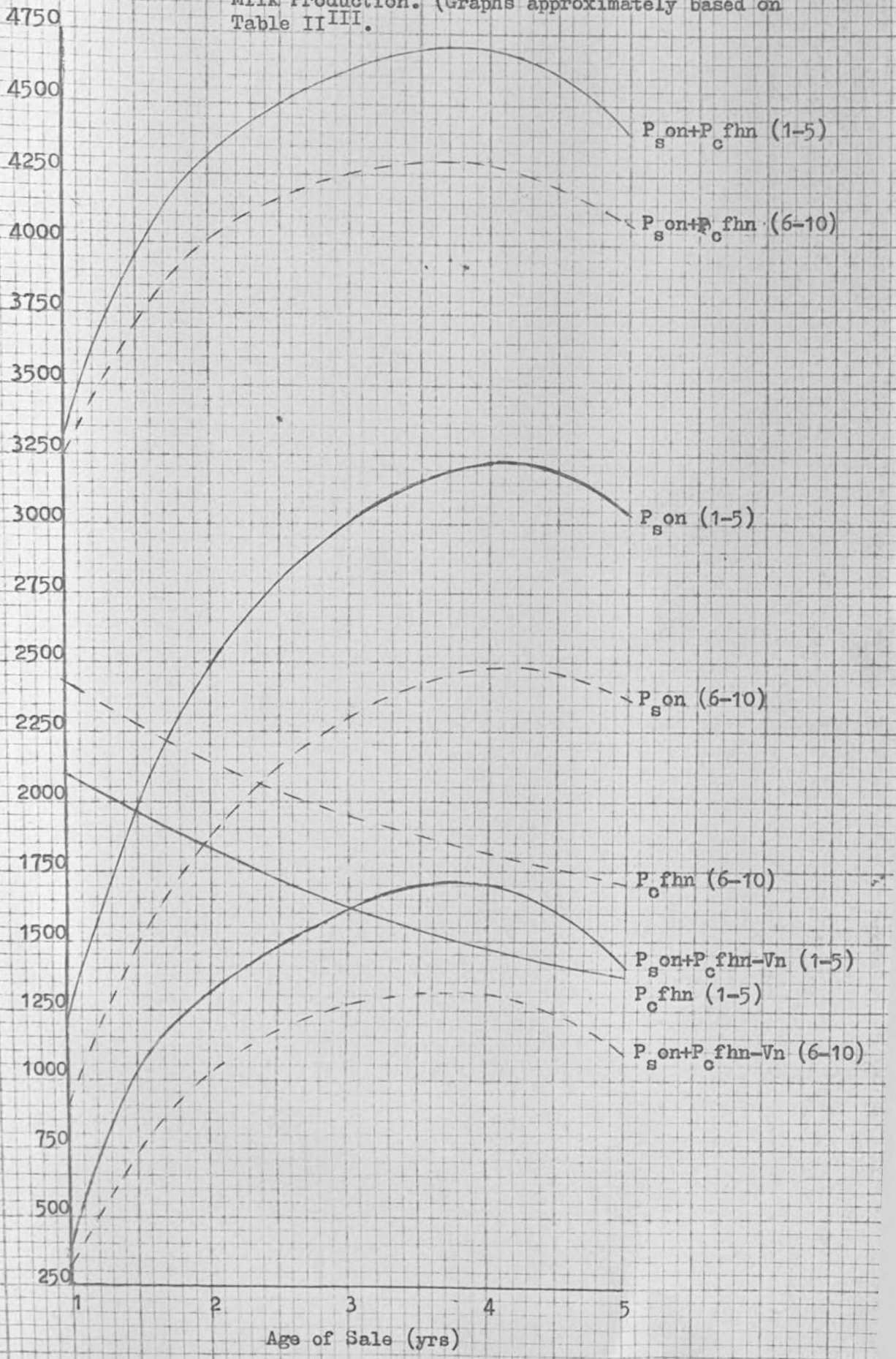
Graph II[VI]. The Influence of the Fraction of the Survival Rate of Immatures (a) on the Percentage of Breeding Females and the Percentage of the Herd Available for Sale with respect to the Age of Sale.



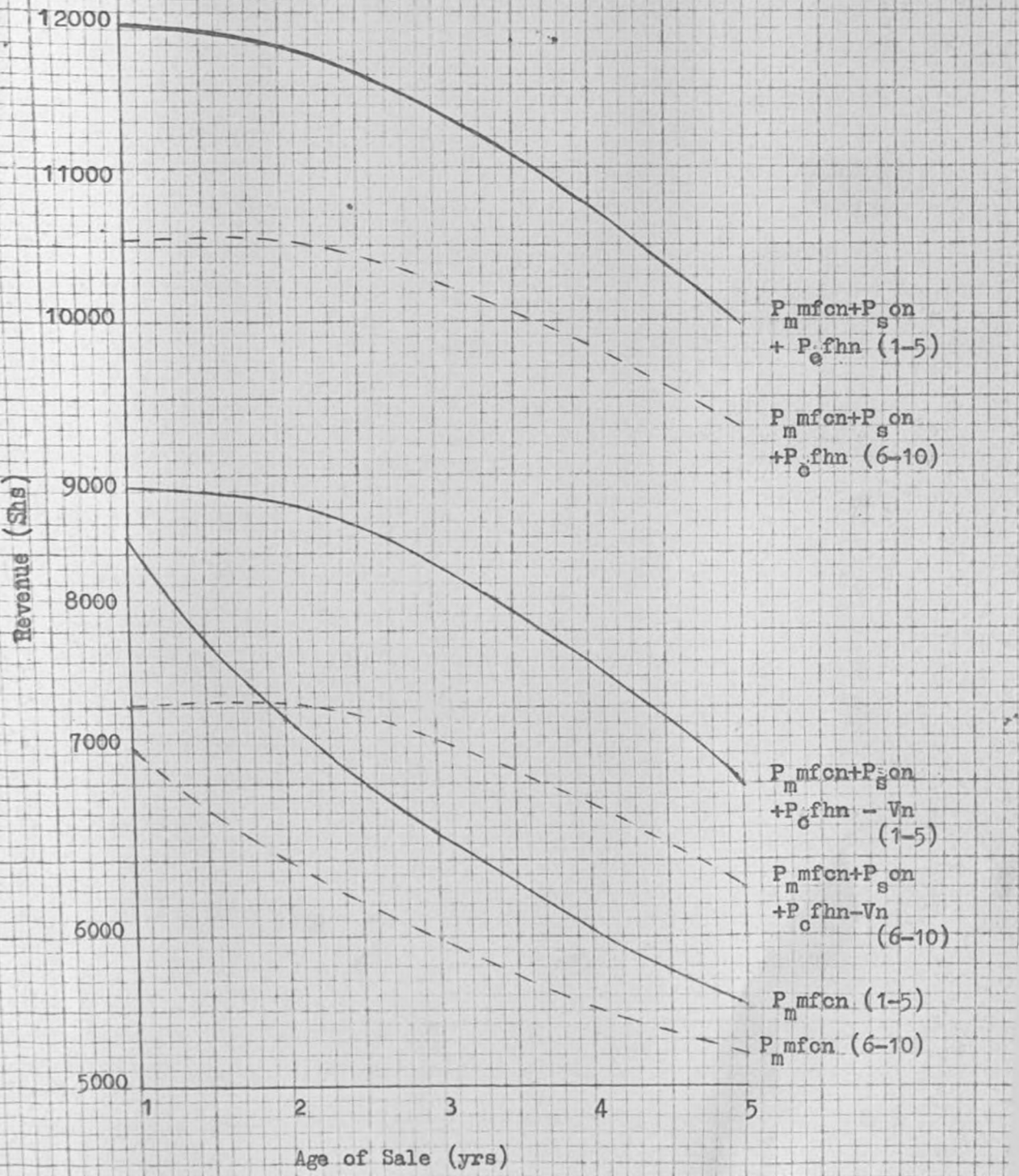
Graph II[VI] (continued)



Graph II[VII]. The Relationship between Potential Revenue and Age of Sale excluding the Value of Subsistence Milk Production. (Graphs approximately based on Table II[III].



Graph II[VIII]. The Relationship between Potential Revenue and the Age of Sale including the Value of Subsistence Milk Production. (Graphs approximately based on Table II[III].



APPENDIX II[1]

ESTIMATED VALUE OF TRADITIONAL SUBSISTENCE ECONOMY IN KAJIADO DISTRICT IN 1973

The difficulties involved in evaluating a subsistence economy often result in them either being undervalued or not taken into account at all. It is the purpose here to evaluate the milk subsistence economy of Kajiado District. Apart from the agriculturalists on the foothills of Kilimanjaro and the four percent of the population living in townships of Ngong and Kajiado (1969 census) the inhabitants of Kajiado District are directly dependent on their cattle. In the main they utilise their herds to provide mainly milk, but also blood, meat and animals for sale to provide cash for necessities. Under the World Bank Livestock Development Plan Phase I, forty-five individual ranches are being developed in Kaputei and around Loitokitok. In addition, nineteen group ranches situated in Kaputei are being developed, but in the main, a traditional economy still exists on these group ranches.

Human Population

The 1969 census gives the population of Kajiado District as 82,565 excluding the townships of Kajiado and Ngong (3,338). The Kenya Statistical Digest projects a figure of 97,000 in 1973 for this area including towns. Therefore, discounting the population in townships, the agriculturalists and individual ranchers, let us assume that there is a population of 85,000 directly dependent on a milk subsistence economy.

Cattle Population

R.M. Watson's Aerial Surveys of 1968-70 estimated that there were 690,000 cattle in Kajiado District. Due to the fact that he carried out the census while he was flying the plane, an error of up to ten percent would be feasible which might bring the estimated population down to 621,000 head. Assuming that the

population has increased to somewhere in the region of 667,500 by 1973 and that 67,500 of these are on individual ranches (average 1,500 per ranch) this means approximately 600,000 head are being traditionally managed.

Milk Production and Consumption

A population of 600,000 cattle being traditionally managed by 85,000 people gives a figure of approximately seven cattle per head. This compares reasonably with David Western's estimate of a high of eight cattle per head and a low of five cattle per head.

Milk production varies according to the grazing and water available so that in good conditions a cow is likely to be producing three and a half litres per day on average but by the end of the dry season this will have fallen to one - one and a half litres per day in areas with access to swamps, and in drier areas a quarter of a litre or less per cow per day. Consumption varies accordingly, falling from three litres or more per head per day in the wet season to practically nil in very dry conditions.

If we assume that on average each person consumes two litres of milk a day over the whole year, that fifty percent of the herd is breeding females and they calve every two years, then total milk production (excluding milk utilised by the calves) is approximately sixty-two million litres per year.

There are two alternative criteria which can be used to evaluate this milk. Firstly, it can be priced at the current market value of milk Shs.1/50 since if the Maasai were existing in a cash economy they would buy an equivalent amount of milk at that price. This puts a value of ninety-three million shillings on milk production.

Secondly, we can price milk by the cost of food which the Maasai buys when his cows are producing little milk. Mike Rainy, in conversation, estimated that for pastoralists in Samburu, Shs.10/- per month per person is spent on posho during drought conditions when the cattle are producing little or no milk. Shs.10/- per month for a population of 85,000 gives a value of 10.2 million shillings. However, this figure can be regarded as a gross underestimation because the nutritional value of posho is considerably lower than that of milk and the Samburu are only able to subsist on this diet for a relatively short time between periods of highly nutritional milk diet. If the assumption is made that the protein value of one litre of milk is equivalent to one quarter of a kilo of meat then the protein value of milk in terms of meat is equal to 15.5 million kilos arbitrarily valued at Shs.5/- per kilo gives 77.5 million shillings. Assuming that a simple posho/meat diet would adequately substitute for the milk diet, this is valued at 87.7 million shillings.

Meat Production and Consumption

Meat is generally only consumed when an animal dies or for ceremonial purposes. For example, one cow is slaughtered at each marriage and during the various moranhood, a total of about six animals are killed. Assume that two and a half percent of the herd are consumed on the range and carcass dead weight is 100 kilos. This gives an average of 17.65 kilos per head (David Western estimates 18-27 kilos of beef per head is consumed in Amboseli) valued at Shs.5/- per kilo is a total of 7.5 million shillings.

In addition, shoat meat is regularly consumed. If we assume a population of 500,000, an offtake rate of thirty percent per year and an average carcass dead weight of 11 kilos, the consumption of shoat meat per head is 19 kilos. (David Western

estimates 11 kilos per head for Amboseli). Using an arbitrarily low value of Shs.2/50 per kilo the total value is 4.125 million shillings. On the other hand the Ministry of Agriculture estimates of the value of locally consumed shoats as follows: 1969 - Shs.298,680/-, 1970 - Shs.670,260/-, 1971 - Shs.670,260/-. This represents three percent (approximately) of the total shoat population but the 1972 estimate of twenty-four percent shoat offtake was valued at 4 million shillings.

Blood Production and Consumption

Blood consumption is significant not for its calorific value but because it is high in vitamins. If each female (assume fifty percent of the herd) is bled twice a month and produces one litre each time, then total blood production for the whole year is 7.2 million litres. If we assume that a nominal Shs.1/- per week per person spent on fruit and vegetables could replace this source of vitamins then one arrives at a figure of 4.42 million shillings.

On-range Utilization of Skins and Hides

The skins and hides of animals consumed on the range are utilised and therefore have a value. If we assume of the cattle and shoats killed for consumption on the range fifty per cent of the hides and skins are utilised and these are priced at Shs.20/- each for cattle hides and Shs.7/- each for shoat skins, then the value of the hides is Shs.150,000/- and skins is Shs.525,000/- giving a total of Shs.675,000/-.

Subsistence Economy

	Million Shillings	
Milk	87.7	(93)
Meat (shoat)	4.125	
(cattle)	7.5	
Blood	4.42	
Hides	.15	
Skins	.525	
Total	104.420	

Value of Cash Economy (based on Ministry of Agriculture figures for 1969-1972 inclusive).

	Shs
Cattle sales	10,000,000
Shoat sales	700,000
Hides sales	300,000
Skins sales	95,000
Total	11,095,000

ON THIS BASIS THE VALUE OF CASH ECONOMY IS APPROXIMATELY 10% OF THE VALUE OF SUBSISTENCE ECONOMY.

APPENDIX II[II]

CALCULATION OF THE PERCENTAGE OF BREEDING FEMALES

In terms of percentage the herd is composed as follows:

% calves	= c f k
% 1–2 year olds	= c f k e
% 2–3 year olds	= c f k e^2 etc
% breeding females	= f
% bulls	= f j

Hence:–

$$100 = c f k + c f k e + \ldots + c f k e^a + (p-a) h f + f + f j$$

$$f = \frac{100}{\left[ck\left(1+e+\ldots+e^a\right)+(p-a)h+1+j\right]}$$

where c is the fraction of breeding females calving each year

k is the survival rate of calves

e is the survival rate of immatures

p is the age of first parturition

a is the age of sale

j is the adult sex ratio

CALCULATION OF THE PERCENTAGE OF THE HERD AVAILABLE FOR SALE

The number of animals available for sale is the number of animals in the selling age group less those required for replacement. i.e. $o = c k e^a f - h f$

substituting from above

$$o = \frac{100\left(ck e^a - h\right)}{\left[ck\left(1+e+\ldots+e^a\right)+(p-a)h+1+j\right]}$$

CHAPTER III

AN EXAMINATION OF SOME OF THE CONCEPTUAL AND ECONOMIC ASPECTS OF WILDLIFE UTILISATION

INTRODUCTION

The plains of Kajiado District can be utilised by two distinct classes of animal life. Firstly, they can be used for livestock ranching which has been subject to an analysis in Chapter II and, secondly, they can be utilised by wild animals. Wildlife differs from domestic stock since, by definition, it is implied that man cannot control population structure, reproduction and movement in the way that he controls these factors in his domestic stock. Since this is the case the possible forms of wildlife utilisation differ greatly from the methods of utilising domestic stock. The status of wildlife utilisation in Kajiado District was outlined in Chapter I. In this Chapter the following forms of wildlife utilisation are examined.

Tourism Wildlife viewing by tourists in Kajiado District is already a well established industry. In terms of monetary value and numbers, viewing by non residents overshadows viewing by residents. Wildlife viewing is, by far, the most economically significant form of wildlife utilisation in Kajiado District and Kenya as a whole.

Safari Hunting Kajiado District is one of the main hunting areas of Kenya and again, in economic terms hunting by overseas visitors is much more important than resident hunting.

Capture While some animals are captured for export as yet it is still on a small scale in this area.

Cropping Although some experimental cropping has been carried out in Kajiado District, there are no plans to introduce any sustained cropping.

This Chapter falls into three Sections. Section I deals with the tourist sector. In this case the tourist sector is considered in two parts: game viewing by non residents and hunting by non residents.

Firstly, it attempts to conceptualise this sector and hence outlines the problems involved.

Secondly, the magnitude and economic value of this sector is discussed.

Section II looks at those forms of utilisation for which the potential level of utilisation bears a direct relationship to the potential offtake rate, namely hunting, cropping and capture.

Firstly, population structure and potential offtake rates are mathematically defined.

Secondly, each activity is examined in terms of its economic value.

Section III compares the potential revenues from each of the main forms of utilisation.

SECTION I

A DISCUSSION OF WILDLIFE-BASED TOURISM

A PROBLEMS OF CONCEPTUALISING THE WILDLIFE-BASED TOURIST INDUSTRY

In economic terms wildlife-based tourism is the most important form of wildlife utilisation in Kenya and the extent of its value is discussed below. Since this industry is of such importance it is essential that the economics of this sector are fully understood, and therefore, the following discussion is concerned with outlining the problems of conceptualising this activity.

The first set of problems arises in attempting to evaluate the wildlife-based tourist industry. Generally speaking a tourist is likely to visit Kenya for a variety of reasons, for example, to stay at the coast and to view game. What criteria should be used to divide his expenditure amongst these various tourist attractions? The simple answer is to attribute the expenditure on each attraction to that sector of the tourist industry. For example, a tourist may visit Kenya and spend his time at the coast and touring some National Parks. The above criteria would allot expenditure at the coast to the coastal attraction and expenditure on visiting National Parks to the wildlife attraction. This is the approach which has been adopted below because of the lack of data on tourist attitudes. However, this may not be satisfactory because it is not known whether the primary reason for his visit was to stay at the coast or to view game or whether he only came because the combined attraction existed in Kenya. If the latter situation is the case then the above criteria holds good but if one particular attraction is the primary reason for visiting Kenya then obviously the primary attraction merits a transfer payment from the secondary attractions. Certainly when evaluating the contribution of each attraction to the National Economy if a particular attraction is a primary attraction it should be valued above the actual expenditure made in that sector. A good example of this situation is the non-resident hunter who only visits Kenya because he can hunt here. He obviously spends money in other sectors but these sectors are only benefiting because the hunting attraction exists. However, while there is obviously a case for adjusting the value of a particular sector depending on whether it is a primary or secondary

attraction, it is difficult to determine the actual amounts because little or no data exists with respect to tourist attitudes towards the existing attractions. In practice if such 'transfer payments' are taken into account their level is likely to be determined on some purely arbitrary basis.

Once the overall value of wildlife-based tourism has been determined, the question of the way in which this revenue is divided amongst the components of the sector arise. For the purpose of this analysis, tourist expenditure on the wildlife viewing attraction can be divided into three major parts: game viewing fees, accommodation and other goods and services. This flow of revenue is shown in Figure III[I].

It is clearly seen that the landowner does not participate in this flow chart even though without wildlife this sector of the tourist industry would not exist. Both Nairobi National Park and the Amboseli Reserve depend on the surrounding ranches as dry season dispersal areas for their game population and yet at the moment there is no transfer payment in effect to these landowners from the other components. A more desirable state of affairs is suggested in Figure III[II].

The second chart suggests that the landowner might directly profit from wildlife by providing accommodation and viewing facilities as well as showing possible routes by which revenue might be returned, via the Government to the landowner. The level of this transfer payment should be determined by the contribution which the wildlife viewing activity makes to the National Economy. Hence, it should be large enough to bring private returns relatively in line with public returns reflecting to the landowner the overall value of wildlife viewing compared to other potential forms of land-use (mainly livestock production in the case of Kajiado District).

FIGURE III[I]: PRESENT WILDLIFE-VIEWING TOURIST REVENUE FLOW CHART FOR KAJIADO DISTRICT

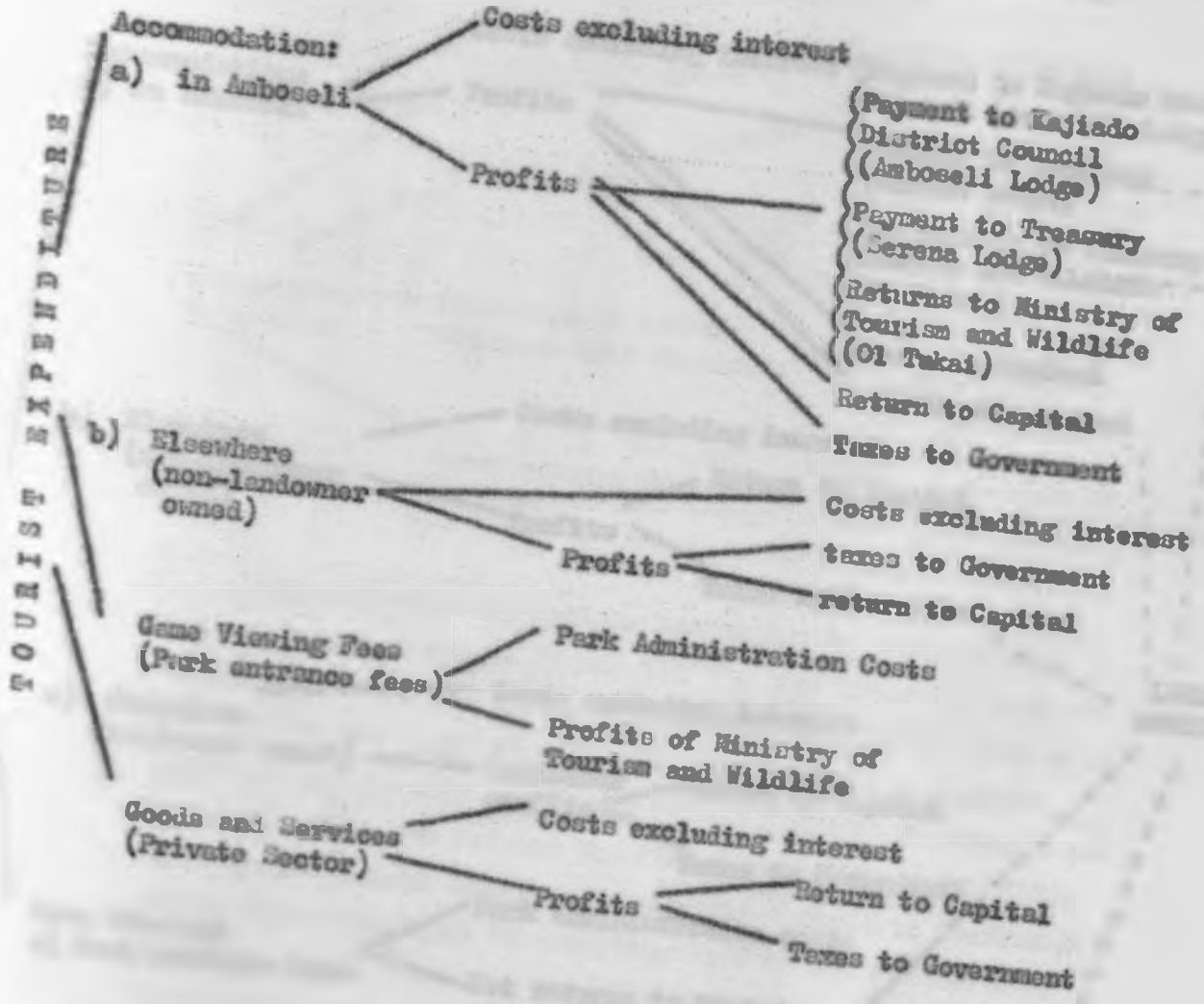


FIGURE III[II]: POTENTIAL WILDLIFE-VIEWING TOURIST REVENUE FLOW CHART FOR KAJIADO DISTRICT

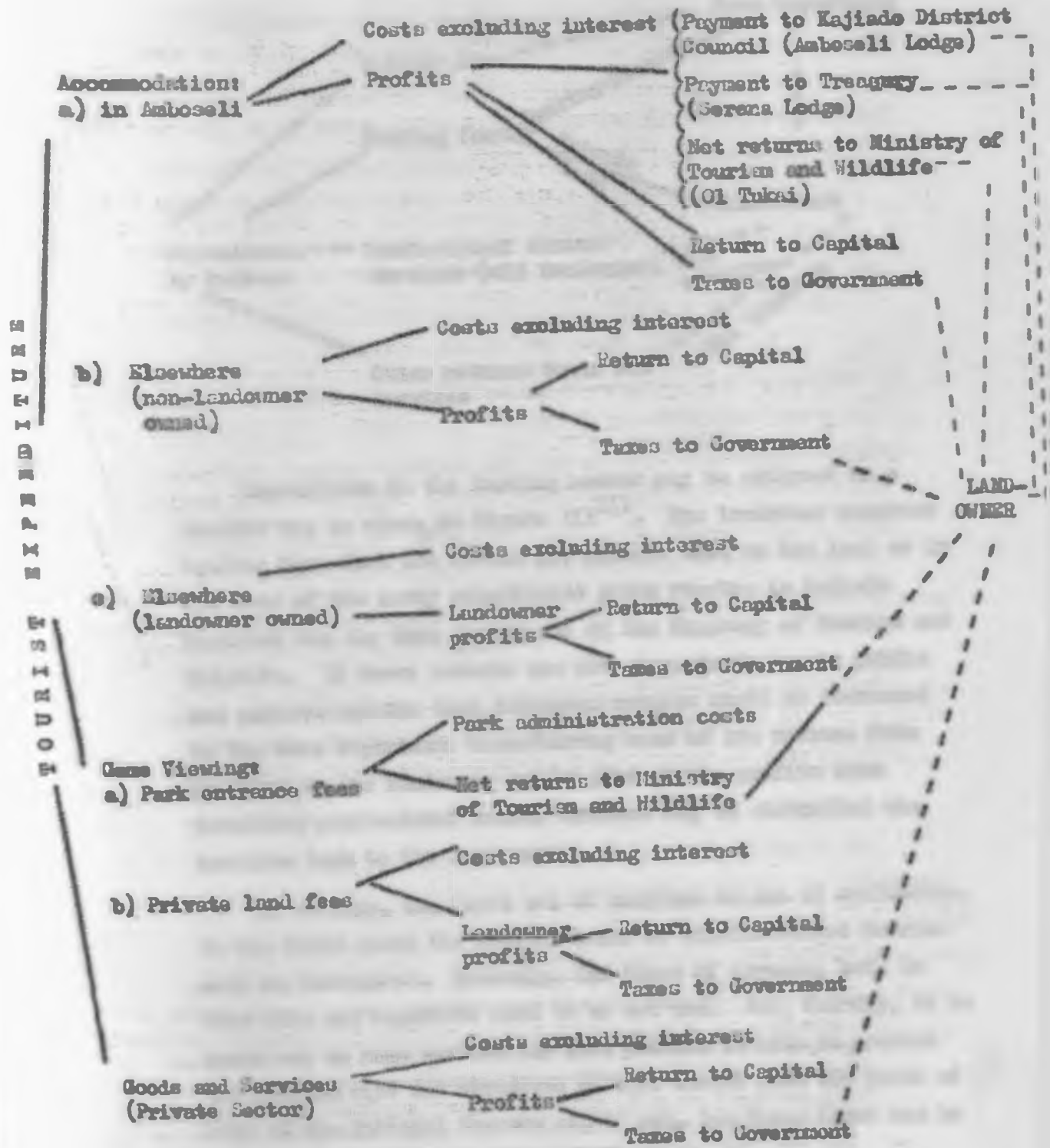
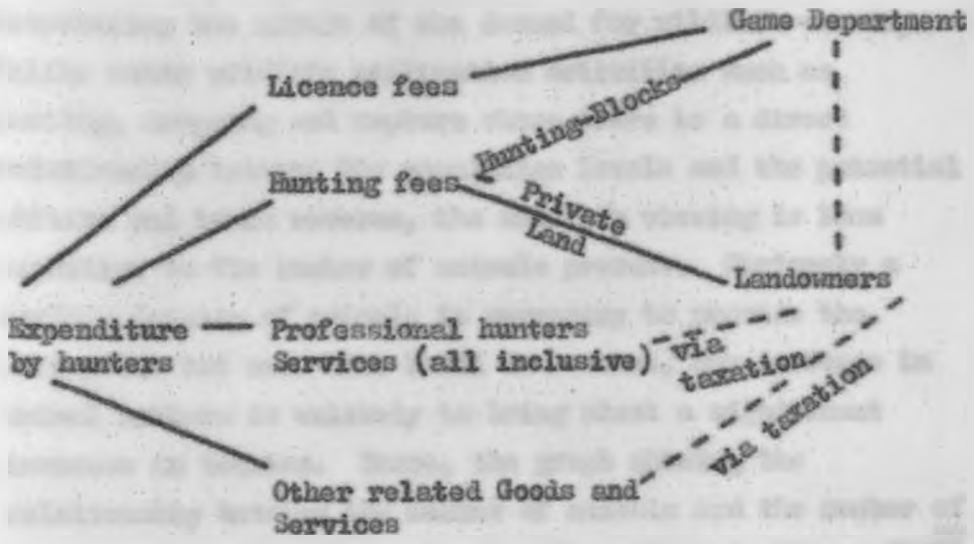


FIGURE III[III]: FLOW CHART OF EXPENDITURE BY HUNTERS



Expenditure in the hunting sector may be analysed in a similar way as shown in Figure III[III]. The landowner receives hunting fees from the hunter for animals shot on his land or in the case of the newly adjudicated group ranches in Kajiado District via the Game Department of the Ministry of Tourism and Wildlife. If these returns are not adequate to equate public and private returns then landowner returns could be increased by the Game Department transferring some of its revenue from licences to the landowner and/or part of the profits from providing professional hunter services may be channelled via taxation back to the landowner.

In summary, the first set of problems is one of evaluation. In the first place the overall value of wildlife-based tourism must be determined. Secondly, the flows of revenue, both in direction and magnitude need to be set out. And, thirdly, it is necessary to know whether the flow pattern is able to produce the optimum size and structure of this sector from the point of view of the National Economy and if not, how these flows can be changed so the optimum situation is achieved.

The second set of problems which arises when conceptualising the tourist sector are basically ones of determining the nature of the demand for wildlife viewing. Unlike other wildlife utilisation activities such as hunting, cropping and capture where there is a direct relationship between the population levels and the potential offtake and hence revenue, the wildlife viewing is less sensitive to the number of animals present. Obviously a certain density of animals is necessary to provide the attraction but once that level is reached, any increase in animal numbers is unlikely to bring about a significant increase in tourism. Hence, the graph showing the relationship between the number of animals and the number of tourists they attract may be shaped as shown in Figure III[IV]. In other words, assuming that the cost of visiting a National Park is not related to the number of animals there then the greater the number of animals the lower the cost of viewing one animal. When the price of viewing one animal falls to the amount that the tourist is prepared to pay then the viewing attraction starts to exist.

However, it is too crude to simply consider the total number of animals and it is necessary to analyse the composition, density and viewing attraction of that wildlife population.

Firstly, the number of different species present is significant in determining the number of visitors to a National Park. Again, there will have to be an adequate number of species present to provide a viewing attraction but once that number is reached the addition of one more species, unless it has a very high viewing attraction, (which is discussed below) is unlikely to significantly influence the number of visitors. Thus, a reasonable shape for the curve representing the relationship

Figure III[I]. The relationship between the number of tourists and the number of animals.

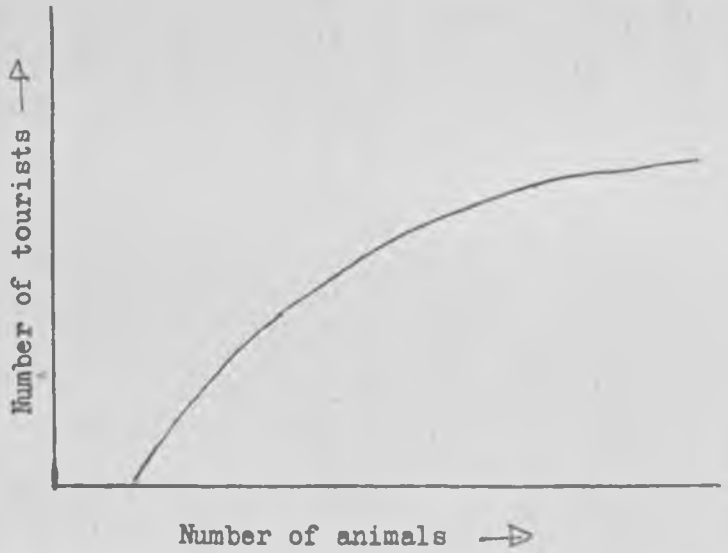
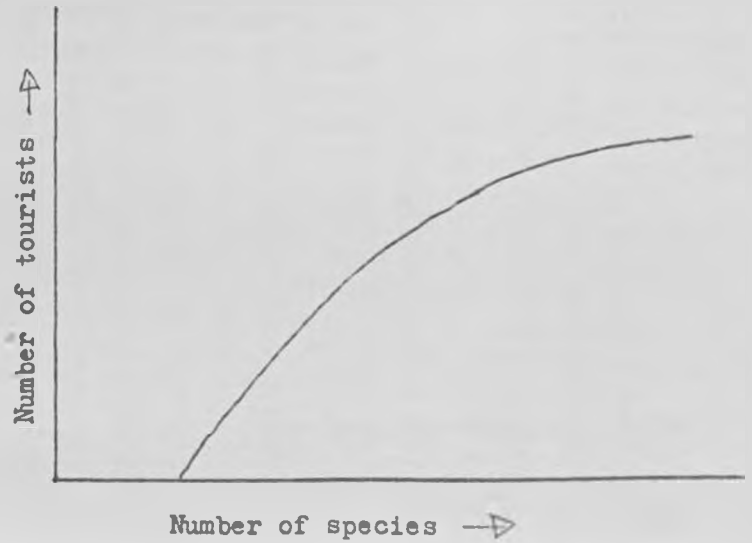


Figure III[II]. The relationship between the number of tourists and the number of species.



between the number of tourists and the number of species would be as illustrated in Figure III[V].

Secondly, each species needs to be present in sufficient numbers so that it can be seen with comparative ease. To some extent the search effort may be rewarding in itself, but on the whole this is only true if the species is numerous enough to be eventually found during the game viewing trip. Hence, a species may be present but if there are only a very small number of individuals then it reduces its value as a viewing attraction. In this case the real issue is the density of each species and it is necessary to have a high enough density of each species. The only exception to this is the case of rare species where even a few animals would provide a high viewing attraction. Once the density is great enough to provide good viewing opportunities, an increase in numbers will have a declining influence on the numbers of visitors. A generalised relationship between the number of tourists and the density of a given species would take the form shown in Figure III[VI].

Of course, the density necessary for a species to provide a viewing attraction and the shape of the relevant curve indicating this relationship will vary according to the species. For example, a fairly low density of lions or rare species such as Greater Kudu, would provide a good viewing attraction and the number of visitors is likely to be responsive to a further increase in density. On the other hand a species such as dik dik would need to achieve a high density to provide a viewing attraction since it is small and not easily seen. The Figure III[VI] can be redrawn for a particular species in the manner illustrated in Figure III[VII].

Figure III[III]. The relationship between the number of tourists and the density of a given species.

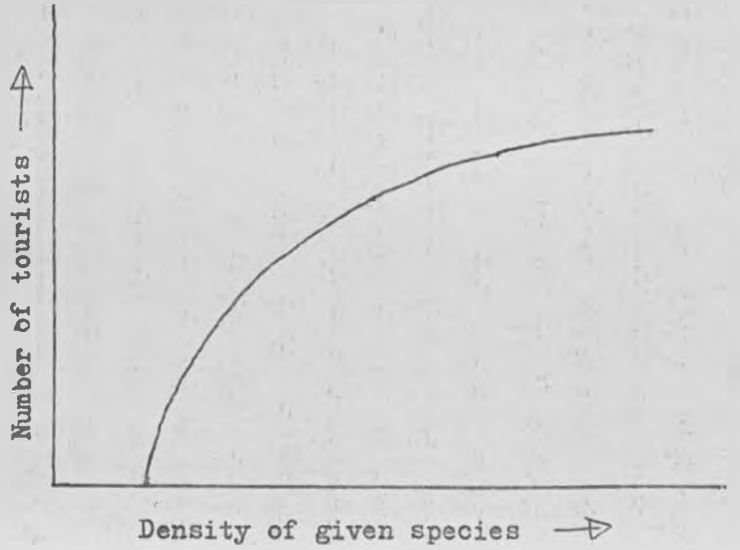
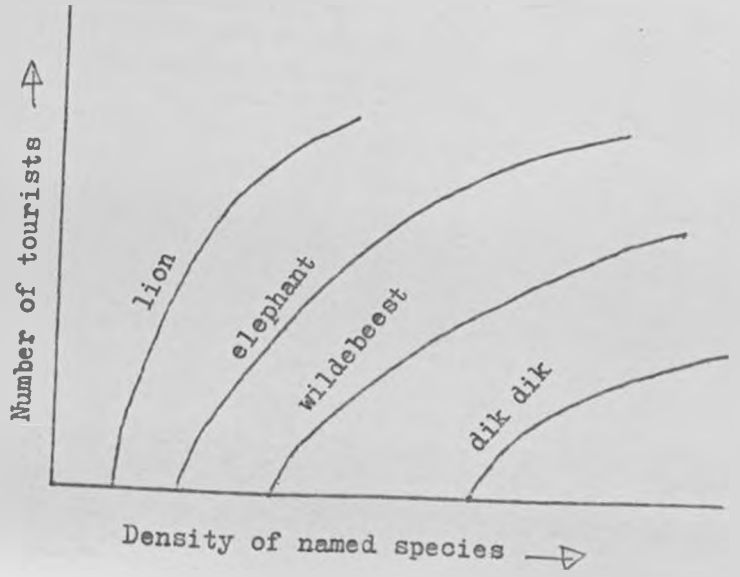


Figure III[IV]. The relationship between the number of tourists and the density of the named species.



The third aspect to be considered is the viewing attraction of each species assuming that it is present in sufficient numbers to provide a viewing attraction. For example, the large well known species (e.g. lion, elephant, rhino) and rare species (e.g. Grevy's zebra, Sable antelope) provide a high viewing attraction while the small and less well known species (e.g. klipspringer) provide a low viewing attraction. Thus, a full circle, to the number of different species present, has been completed since the viewing attraction of a given area is not only determined by the number of species present but also by the type of species. In other words, we are concerned with the diversity index of a given area. It is necessary for an area to have species which possess a high viewing attraction for that area to attract visitors. For example, an area with fifty species of small birds will attract far fewer visitors than another area containing fifty species composed of large and medium sized carnivores and herbivores. The graph relating the number of visitors to the number of species must be used with care in that since there is such a difference in viewing attraction according to species, the population must be defined according to the type of species as well as the number of species. The effect of the removal of one species on the total number of visitors will be dependent on the other species present. For example, if a species which has a low viewing attraction is removed it is unlikely to influence visitor numbers. On the other hand, if a species with a high viewing attraction is removed it will influence visitor numbers according to the species mix present. In other words the greater the number of species with a high viewing attraction in that area the less the influence of removing a high attraction species.

In brief, the tourist demand for a wildlife viewing area depends not only on the number of animals present but also the number, type and density of species present. It should also be remembered that the quality of the environment can add to, or detract from, the viewing attraction of a given area.

B THE VALUE AND MAGNITUDE OF WILDLIFE-BASED TOURISM IN KAJIADO DISTRICT

The problems of obtaining adequate and accurate data are discussed elsewhere and as with other wildlife utilisation activities this makes an accurate assessment of the value of wildlife-based tourism difficult. Since no published data is forthcoming from either the National Parks or the Game Department of the Ministry of Tourism and Wildlife, the main source of data used here is the Economic Survey - 1974. However, not only is most of the data compounded but also it contains no information about Amboseli Reserve. Therefore, data relating to this area has been taken from "Development Plans for Amboseli" by Western and Thresher. The following estimates although crude, through necessity serve to show the importance of the tourist industry compared to other forms of wildlife utilisation.

In 1973 the tourist industry was worth Shs.486 m of which 7.3% is attributable to hunting. It is assumed that since the Wildlife Management Project estimated that in 1972 hunting accounted for 7.3% of tourist revenue this would also be a realistic estimate for 1973. In other words tourism excluding hunting was worth 450.5 million shillings. Since bednight occupancy by non-residents was 2,784,000 in 1973 the average daily expenditure by non-hunting tourists amounted to Shs.161.82 for all visitors to Kenya.

The Value of Wildlife Viewing in Amboseli

Western and Thresher estimate that 55,250 (an average of their high and low forecasts) non-residents visited Amboseli in 1973. If only one day's expenditure is attributed to each tourist then this amounts to Shs.8,940,555. They also estimate that 21,900 residents visited Amboseli in that year. If we assume that each resident spends an average of Shs.100/- in that area on food, accommodation, souvenirs and so on, then revenue from residents is Shs.2,190,000. Therefore, total expenditure by residents and non-residents is Shs.11,130,555 per annum. This is a minimum figure since the purpose of the visit is to spend time viewing game and therefore, no tourist would spend less than one day in this area.

The Value of Wildlife Viewing in Nairobi National Park

The following assumptions have been made in relation to the value of tourism in Nairobi National Park. Firstly, each non-resident visit is accounted for at the rate of one day's average daily expenditure since it is supposed the tourist will also spend a night in Nairobi thus effectively spending a whole day in the Nairobi area. Secondly, each resident visit is valued at Shs.10/-. This is made up of Shs.5/- entrance fee plus Shs.5/- towards the vehicle entrance fee. Thirdly, it is assumed that season ticket holders visit the park frequently enough to make the purchase of a ticket worthwhile. Therefore, season ticket holders visits are valued at Shs.5/- each.

The Value of Wildlife Viewing in Nairobi National Park in 1973

	Number of Visits	Value (Shs)
Non-residents	70,250	11,376,855
Residents	104,809	1,048,090
Season Ticket Holders	37,992	189,960
Children	62,224	62,224
Total - Residents		1,300,274
- Residents + Non-residents		12,677,129

Although the above estimate shows visits to Nairobi Park to be worth Shs.12,677,129 this is an under estimate because there is no published data about visitors to the Animal Orphanage.

The Total Value of Tourism in Kajiado District

The combined value of tourism to Nairobi Park and Amboseli amounts to Shs.23,807,684 or over 5¼% of the total national revenue from non-hunters. If we assume that Kajiado District accounts for 20% of all non-resident hunting (based on controlled area fees earned by that area) then in 1973 Kajiado District earned Shs.7.1 million from hunting or nearly 1½% of total tourist revenue. In other words the combined revenue from viewing and hunting in Kajiado District was Shs.30,907,684 or 6.4% of the total value of tourism. The most striking feature regarding the distribution of this revenue is that currently the landowner who supports the wildlife does not share in the revenue it earns. Obviously this is a most unsatisfactory state of affairs in terms of inducing optimum patterns and levels of wildlife utilisation and this question of income redistribution is discussed elsewhere.

SECTION II

A CONSIDERATION OF THE HUNTING, CROPPING AND CAPTURE ACTIVITIES

A A MATHEMATICAL DEFINITION OF THE HERD STRUCTURE OF PLAINS GAME POPULATIONS AND POTENTIAL OFFTAKE RATES

Introduction

The area of consideration is the population structure of plains game and the potential offtake rates from these populations. The objective is to conceptually express population structure in a mathematical form and then examine the effect of population structure on potential offtake rates. It should be

pointed out that given the present state of knowledge it is not possible to feed accurate data into the following equations which have been developed, and therefore the concept has been exemplified by taking a range of probable values of the variables which affect population structure and calculating the resulting population growth rates and removal rates. In practice this approach has been developed for use in the future when further research has provided the relevant data.

This approach is intended to study the static situation. That is, given a set of data for a particular population, population growth rate, removal rate and hence potential offtake rate can be calculated on the basis of the assumption that the existing population level is to be maintained. However, to a certain extent this concept can be modified to determine the long term situation in that potential offtake rates can be plotted against changes in the variables which are assumed to occur over time.

Variables Influencing Population Structure

The initial objective is to develop population structure formulae which will assist in understanding the static situation. For this purpose, only endogenous variables are considered. However, the effects of exogenous influences which are relatively constant over time are included because these factors are implicit in the endogenous variables. For example, predator impact is implicit in the calf and adult survival rates. Those external factors which effect population structure in a non-uniform manner over time or are not implicit in the endogenous variables are not taken into account because they do not assist in understanding the static situation. Thus, the effect of drought on population structure would be excluded, although it is, of course, recognised that such external factors will have a long term influence on population structure.

The following endogenous variables are assumed to influence population structure:-

The percentage of breeding females which calve down in any one year (c)

'c' is the fraction of the breeding females which calve down each year. Hence 'c' is greater than or equal to zero and for the purposes of this analysis it is assumed to be less than 1.4. This is possible since some species have a breeding cycle of less than one year.

Age of sexual maturity (p)

'p' is the age of the first parturition.

Number of young in each parturition (y)

Obviously 'y' is greater than or equal to 1 and it is assumed that 'y' is less than 1.4 for the purposes of this analysis.

Survival rate of calves (k)

'k' is the fraction of calves born which are still alive at one year old.

Survival rate of animals over 1 year old (s)

's' is the fraction of animals over one year old which survive over a period of one year.

Longevity (l)

'l' is the number of age groups, on a yearly basis, of animals over one year old, in which there is a significant number of animals. A significant percentage of the herd will, to some extent, depend on the longevity of the given species.

Adult sex ratio (j)

This can be expressed in a variety of ways depending on the method of constructing population structure formulae.

e.g. $j = \frac{\text{percentage of adult males}}{\text{percentage of adult females}}$

$j = \frac{\text{number of adult males}}{\text{number of adult females}}$

$j = \frac{\text{number of adult males}}{\text{total number of adults}}$

For the purposes of this analysis the former definition has been used.

The percentage of breeding females (f)

'f' is the number of breeding females expressed as a percentage of the total herd.

Assumptions

In building up the formulae in the subsequent section the following assumptions have been made.

Firstly, the sex ratio in each age group of sexually mature animals is constant.

Secondly, males and females become sexually mature at approximately the same age. This assumption is made in order to simplify the analysis although it does not hold true for all species. Conceptually the analysis can be extended to allow for differing ages of sexual maturity, e.g. buffalo.

Thirdly, reproductive life extends from the age of sexual maturity until death. 'c' represents the fraction of breeding females calving in a given year and therefore decreased fertility with old age is implicit in the value of 'c'.

Population Structure Formulae

A feature of all the following formulae is that each category of animals within the population is expressed as a percentage of the total population. Thus, this analysis is independent of knowledge of actual numbers and yet given the relevant data the numbers of animals in each category can be easily computed.

The percentage of breeding females is a significant variable in the determination of potential population growth rates and hence potential offtake rates. And since this paper is concerned with determining potential offtake rates the following population structure formulae have been manipulated to express the percentage of breeding females as a function of the other variables set out above which influence population structure.

Population structure formulae are developed using the following principle: 100% of the population is the sum total of the different categories of animals making up that population expressed as percentages of the total. Thus, for example the percentage of calves born is represented by 'c f y' while 'f j' gives the percentage of bulls. There are a variety of criteria (e.g. sex, age) which may be used to categorise the population depending on the objective involved. Some of these are shown by the following alternative formulae all of which are conceptually and mathematically correct.

Formulae A:

$$100 = cfy\left(\frac{1+k}{2}\right) + cfyk\left(\frac{1+s}{2}\right) + cfyks\left(\frac{1+s}{2}\right) + \ldots$$

$$\ldots + cfyks^{p-2} + f + fj$$

$$100 = \frac{f}{2}\left(cy\left[1 + k + k(1+s)(s^0 + \ldots + s^{p-2})\right] + 2 + 2j\right)$$

$$\therefore f = \frac{200}{\left(cy\left[1+k+k(1+s)(s^0 + \ldots + s^{p-2})\right] + 2 + 2j\right)}$$

(when p is less than 2 let $(s^0 + \ldots + s^{p-2}) = 0$

Formula B:

Formulae A was independent of longevity. This variable is included in formula B but is independent of the sex ratio and the age of first parturition.

$$100 = ofy\ \frac{(1+k)}{2} + ofyks^0\ \frac{(1+s)}{2} + ofyks\ \frac{(1+s)}{2}$$

$$+ ofyks^2\ \frac{(1+s)}{2} + \ldots + ofyks^{l-1}\ \frac{(1+s)}{2}$$

$$= \frac{ofy}{2}\left[1 + k + k\,(1+s)(s^0 + s^1 + \ldots + s^{l-1})\right]$$

$$f = \frac{200}{cy\left[1 + k + k\,(1+s)(s^0 + s^1 + \ldots + s^{l-1})\right]}$$

Formula C:

Formula C is constructed so that all the variables listed above are included.

$$100 = ofy\ \frac{(1+k)}{2} + ofyks^0\ \frac{(1+s)}{2} + ofyks\ \frac{(1+s)}{2} + \ldots$$

$$\ldots + ofyks^{p-2}\ \frac{(1+s)}{2} + f + ofyks^{p-1}\ \frac{(s+1)}{2}\,j + \ldots$$

$$\ldots + ofyks^{l-1}\ \frac{(s+1)}{2}\,j$$

$$= \frac{f}{2}\,(cy + cyk + cyk\,(1+s)(s^0 + s + \ldots + s^{p-2}) + 2$$

$$+ cyk\,(1+s)(s^{p-1} + \ldots + s^{l-1})\,j$$

$$f = \frac{200}{(cy\left[1+k+k\,(1+s)(s^0 + s + \ldots + s^{p-2} + j\,s^{p-1} + \ldots j\,s^{l+1})\right]+2)}$$

(when p is less than 2 let $(s^0 + \ldots + s^{p-2}) = 0$)

Formula D:

In the previous formulae, survival rate of animals over one year old has been taken as uniform but conceptually it is easy to extend the formula so a different survival rate can be written in for each age group. Taking formula B for example:-

$$100 = cyf\ \frac{(1+k)}{2} + cyfk\ \frac{(1+s_1)}{2} + cyfks_1\ \frac{(1+s_2)}{2}$$

$$+ cyfks_1s_2\ \frac{(1+s_3)}{2} + \ldots + cyfk\ (s_1x \ldots xs_{l-1}\ \frac{(1+s_l)}{2})$$

$$100 = \frac{cyf}{2}\ /1 + k + k + ks_1 + ks_1 + ks_1s_2 + ks_1s_2s_3 + \ldots$$

$$+ (ks_1x \ldots xks_{l-1}) + (ks_1x \ldots xks_l)/$$

$$100 = \frac{cyf}{2}\ (1 + 2k\ /1 + s_1 + s_1s_2 + s_1s_2s_3 + \ldots (s_1x \ldots xs_{l-1})/ + k\ (s_1x \ldots xs_l))$$

$$f = \frac{200}{cy\ (1+2k\ /1+s_1+s_1s_2+s_1s_2s_3 + \ldots + (s_1x \ldots xs_{l-1})/+k(s_1x..xs_l))}$$

Herd Growth Rate Formula

Let the percentage increase in herd size per annum be 'i' where 'i' = cfy

and the percentage decrease in herd size per annum be 'd' where d = cfy (1 - k) + (100 - cfyk)(1 - s)

and let the net increase in herd size per annum be 'r' where r = i-d.

Hence $r = cfy - /cfy\ (1-k) + (100 - cfyk)(1-s)/$

$$r = cfyk\ (2-s) + 100\ (s-1)$$

when 'r' is greater than zero the herd size is increasing over time.

When r = o the herd size is constant over time.

when 'r' is less than zero the herd size is decreasing over time.

Thus, 'r' gives the potential offtake rate if the objective is to maintain a stationary population provided 'r' is greater than zero.

Derivation of Removal Rate Formula (R)

In this case the removal rate is defined as the number of animals over one year old, expressed as a percentage of the total herd, which must be removed from the herd either through natural losses or consumptive utilisation in order to maintain a stationary population (i.e. r = s). It should be pointed out that a stationary population will only be maintained if the removal rate for each category of animal is proportionate to the numerical size of that category thus maintaining the existing population structure.

It is particularly appropriate to consider the removal rate because one of the main influences on the mortality rate is population pressure assuming that the population is greater than or equal to the carrying capacity. Consumptive utilisation, namely cropping, hunting and live capture, will reduce population pressure and the resulting natural mortality rate but the removal rate will remain constant for any given set of the values of the variables which determine the removal rate.

Thus the removal rate can be expressed as follows:-

$$R = d + u$$

where 'd' is the percentage of the total population which dies through natural causes (e.g. predation, disease) each year.

Where 'u' is the percentage of the total population which is removed through consumptive utilisation.

Since, if the population is at carrying capacity or above, population pressure is one of the variables determining the percentage of the population which dies due to natural causes and consumptive utilisation reduces the effect of this variable then we can write

$$d = f(u)$$

hence 'R' can now be written

$$R = f(u) + u$$

Using the set of variables set out above and the formulae which have been developed the removal rate can be determined as follows:-

The removal rate is defined as the percentage of the herd which must be removed in order to maintain a stationary population over time.

Thus $i = d$ and let this specific value of 's' be 's_1'.

From the above formula:

$$cfy = cfy(1-k) + (100 - cfyk)(1 - s_1)$$

$$cfy = cfy - cfyk + 100 - cfyk - 100s + cfyks_1$$

$$100 - 2\,cfyk - 100s + cfyks_1 = 0$$

Substitute $f = \dfrac{200}{(cy\,[1+k+k\,(1+s_1)(s_1^0 + \ldots + s_1^{p-2})]+2+2j)}$

(Any of the above formulae for determining the percentage of breeding females could be used depending on the objectives involved. For the purposes of exemplifying this method of determining the removal rate formula 'A' is adequate).

$$100 - 100s_1 + \frac{200\,cyks_1 - 400\,cyk}{(cy\,[1+k+k\,(1+s_1)(s_1^0 + \ldots + s_1^{p-2})]+2+2j)} = 0$$

$$(1-s_1)(cy\,[1+k+k\,(1+s_1)(s_1^0 + \ldots + s_1^{p-2})+2+2j] - 4\,cyk + 2\,cyks_1 = 0$$

$$cy + cyk + cyk\,(1+s_1)(s_1^0 + \ldots + s_1^{p-2}) + 2+2j - cys_1$$

$$- cyks_1 - cyks_1\,(1+s_1)(s_1^0 + \ldots + s_1^{p-2}) - 2\,s_1 - 2\,js_1$$

$$- 4\,cyk + 2\,cyks_1 = 0$$

$$cy - 3\,cyk + 2 + 2j - 2\,s_1 - 2\,js_1 - cys_1$$

$$+ cyks_1 + cyk\,(s_1^0 + \ldots + s_1^{p-2}) - cyks_1^2\,(s_1^0 + \ldots + s_1^{p-2}) = 0$$

$$cy - 3\,cyk + 2 + 2j - 2s_1 - 2\,js_1 - cys_1 + cyks_1$$

$$+ cyks_1^{0} + cyks_1 - cyks_1^{p-1} - cyks_1^{p} = 0$$

$$cyks_1^{p} + cyks_1^{p-1} + (2+2j+cy - 2\,cyk)s_1 - (2+2j+cy - 2cyk) = 0$$

Let $cyk = A$

and $2 + 2j + cy - 2\,cyk = B$

then $As_1^{p} + As_1^{p-1} + Bs_1 - B = 0$

The survival rate of animals over one year old such that the population remains stationary, 's_1' is determined by solving this equation for the appropriate values of the survival rate of calves, the number of young in each parturition, the percentage of females calving per annum, the sex ratio and the age of first parturition. By way of an example 's_1' is solved in general terms for the age of first parturition being one, two and three years old.

when $p = 1$

$$As_1 + A + Bs_1 - B = 0$$

$$s_1 = \frac{B - A}{A + B}$$

$$\therefore s_1 = \frac{2 + 2j + cy - 3\,cyk}{2 + 2j + cy - cyk}$$

when $p = 2$

$$As_1^{2} + As_1 + Bs_1 - B = 0$$

$$As_1^{2} + (A + B)s_1 - B = 0$$

Using the general formula for the roots of a quadratic equation

$$Y = \frac{-D \pm \text{square root}\,(D^2 - 4\,CE)}{2C}$$

where $CY^2 + DY + E = 0$

$$s_1 = \frac{-(A+B) \pm \text{square root}\left[(A+B)^2 - 4AB\right]}{2A}$$

$$s_1 = \frac{-2-2j-cy+cyk \pm \text{square root}\left[(2+2j+cy-cyk)^2 + 4\,cyk\,(cy-2cyk+2j+2)\right]}{2\,cyk}$$

By definition

'j' is greater than zero

'c' is greater than or equal to zero and less than 1.4

'y' is greater than or equal to zero and less than 1.4

'k' is greater than or equal to zero and less than or equal to unity

Therefore:- $4\,cyk\,(cy+2cyk+2+2j)$

$= 4\,cyk\,[cy\,(1-2k)+2+2j]$ is greater than zero

Hence $(2+2j+cy+cyk)^2 + 4\,cyk\,(cy - 2\,cyk + 2+2j)$ is greater than zero

Therefore this equation has two real roots

$2 + 2j + cy$ is greater than cyk

and $\text{square root}\left[(2+2j+cy-cyk)^2 + 4cyk\,(cy-2cyk+2y+2)\right]$ is greater than $(-2-2j-cy+cyk)$

Therefore this equation has one positive root. It is this real positive root which gives us the appropriate value of 's_1'.

<u>when n = 3</u>

$$As_1^3 + Bs_1^2 + Ds_1 - E = 0$$

There is no formula for determining the roots of a cubic equation therefore let one root of this equation be 'z' and determine it by trial and error using the appropriate computer programme.

By definition 's' is greater than or equal to zero and less than or equal to unity, therefore one root of this equation must lie between zero and one. Let 'z' be this root then

$$(s_1 - z)(s_1^2 + (1 + z)\, s_1 + (B/A + (1 + z)\, z) = 0$$

using the general formula for the solution of a quadratic equation

$$Y = \frac{-D \pm \text{square root } (D^2 - 4CE)}{2C}$$

where $CY^2 + DY + E = 0$

$$s_1 = \frac{-(1 + z) \pm \text{square root } \left[(1 + z)^2 - 4\,(B/A + (1 + z)\, z\right]}{2}$$

By definition

'z' is greater than or equal to zero and less than or equal to unity

'j' is greater than zero

'c' is greater than or equal to zero and less than 1.4

'y' is greater than or equal to zero and less than 1.4

'k' is greater than or equal to zero and less than or equal to unity

Therefore $B = 2j + 2 + cy\,(1-2k)$ is greater than unity and B/A is greater than unity

$$(1 + z)^2 - 4\,(B/A + (1 + z)\, z) = 1 + 2z + 2z^2 - 4\,B/A - 4z - 4z^2$$
$$= 1 - 2z - 3z^2 - 4\,B/A \text{ which is less than zero}$$

Hence there are no real roots to the equation

$$s_1^2 + (1 + z)\, s_1 + (B/A + (1 + z)\, z) = 0$$

Thus, the equation $Ak^3 + Bk^2 + Ek - B = 0$

has only one real root 'z' and this is the appropriate value of 's'$_1$

Using the value of 's' for which $i = d$ (ie s_1)

$$R = \left[100 - cyf \frac{(1+k)}{2}\right] / (1 - s_1)$$

substitute $f = \dfrac{200}{cy\left[1+k+k(1+s_1)(s_1^{\circ} + \ldots + s_1^{p-2})\right]+2+2j}$

$$R = 100(1-s_1) - \frac{200\,cy\,(1+k)(1-s_1)}{2\left(cy\left[1+k+k(1+s_1)(s_1^{\circ} + \ldots + s_1^{p-2})\right]+2+2j\right)}$$

$$= \frac{100(1-s_1)\left[cy + cyk + cyk(1+s_1)(s_1^{\circ}+\ldots+ s_1^{\circ}+\ldots+ s_1^{p-2})+2+2j-cy-cyk\right]}{cy\left[1+k+k(1+s_1)(s_1^{\circ} + \ldots + s_1^{p-2})\right]+2+2j}$$

$$\therefore R = \frac{100(1-s_1)\left[cyk(1+s_1)(s_1^{\circ} + \ldots + s_1^{p-2}) +2+2j\right]}{cy\left[1+k+k(1+s_1)(s_1^{\circ} + \ldots + s_1^{p-2})\right]+2+2j}$$

Utilisation of Preceding Formulae

In order to exemplify the use of the formulae which have been set out above, Table III[I] has been worked out. On the left hand side of the table a range of feasible values of the survival of animals over one year old (s) and calves (k), the percentage of breeding females calving down per annum (c) the number of young in each parturition (y) the sex ratio (j) and the age of first parturition (p) are set out. For each of these combinations of values the percentage of breeding females (f) the potential total increase in herd size (i), the net population growth rate (r), the survival rate of animals over one year old such that the population remains stationary (s_1) and the removal rate (R) have been calculated. These figures not only show the order of magnitude of potential population growth rates and removal rates given a particular set of values, but also, the effect of a change in value of a particular variable on the potential population growth rate and removal rate.

Human Influence on Population Structure

Let us consider the variables listed above as influencing population structure. Out of the seven variables discussed there are only two which man may be able to significantly change. The first is the possibility of lowering mortality rates by reducing population pressure through consumptive utilisation. The concept of a removal rate is a blanket concept which covers both natural mortality and consumptive utilisation. Through cropping and hunting it may be possible to lower population pressure thus improving the potential increase in population and hence potential offtake rates for utilisation. However, this relationship can only be determined by zoologists and in the meantime the use of a removal rate gives a meaningful indication of potential offtake rates. Once the form of

$$d = f(u)$$

has been determined then the removal rate can be calculated using the appropriate values of the variables involved and hence the percentage of the herd which can be utilised by man can be deduced from the equation:

$$R = f(u) + u$$

The other variables which can be changed by man in the process of consumptive utilisation is the sex ratio. Using the sets of data discussed above, the removal rate (R) and the net growth rate of the population (r) have been calculated for a range of values of the sex ratio (j) and are set out in Table III[II]. It is clearly shown that as the sex ratio decreases so the population growth rate and the removal rate increase and this is particularly marked the lower the age of first parturition. This indicates that if the main objective is to maximise offtake irrespective of sex and age, as in a cropping

operation, then it is advantageous to lower the sex ratio. But, for genetic reasons it is desirable to keep more males than are required to serve the breeding females. On the other hand, for utilisation activities such as hunting where the sex and age of the animal are important, then the desirable sex ratio will depend on the prevailing requirements. In other words, hunters generally want large male trophies so it is necessary to bias the population structure towards an increased proportion of older males.

However, human influence which alters the sex ratios and age structures may have the undesirable effect of lowering the reproductive rates and hence the potential offtake rates, instead of simply reducing the natural losses resulting from population pressure, and hence increasing the potential offtake rate. Social organisation which is specific to each species greatly influences breeding success and thus the increase in population. Any form of utilisation which upsets the population structure, and therefore also social behaviour, may result in a lower reproductive rate.

Conclusion

In the preceding pages an attempt has been made to set out a mathematical definition of plains game population structures and then use these formulae to calculate removal rates which are a function of potential offtake rates. This approach has been exemplified by working out a few numerical examples. The removal rates in the examples worked in Table III[I] appear remarkably high but the reasons for this are as follows. Firstly, the values of the variables used are favourable and secondly, this figure includes death through natural causes which will vary greatly according to conditions. For example, a drought will greatly increase natural mortality rates. Finally, consideration has been given to how man might influence potential offtake rates by manipulating population structure.

B Some Aspects of the Economic Value of Hunting, Cropping and Capture *

Part A of this Section was concerned with a mathematical definition of potential offtake rates, while this part goes on to consider the revenues that can be gained from this offtake and how that revenue can be maximised. It is also of importance to examine the flows of revenue since it is in the interests of the Kenyan economy that private returns are equated with national returns in all sectors. Therefore, the value of hunting, cropping and capture will be discussed in terms of where the revenue flows as well as the magnitude of this revenue.

HUNTING

The hunting industry can be considered in two parts: resident hunting and non resident hunting. In terms of economic value they are two different propositions. Generally speaking, the resident hunter provides his own equipment and hires his own staff. On the other hand a non resident hunter is required to employ the services of a professional hunter who then provides all the necessary goods and services. The significant difference is not only in the cost per day but also because the cost to the overseas hunter represents foreign exchange earnings for Kenya.

Revenue from hunting can be considered in two ways: in terms of flows of revenue to the involved parties or in terms of total returns and returns per animal. The latter is discussed in Section III while the former is considered below.

Returns to Landowner

It is anticipated that hunting in Kajiado District will be managed by the Wildlife Management Project and it will be responsible for directing some of the revenues from hunting to the landowners on criteria that have not yet been fully determined. This revenue will be composed of two parts: firstly,

* Data provided by UNDP/FAO Wildlife Management Project.

the hunting fees which are paid for each animal shot as laid down in Table III[III] and, secondly, the booking fees payable at the rate of Shs.5 per day for residents and Shs.10 per day for non residents. If the system is altered to one where each rancher draws up a private agreement with the hunter then it is possible that the return per animal may be higher than the standardised hunting fees. For example, a safari operator in Nairobi was charging private land fees as set out in Table III[IV] and it can be seen that these are considerably above the hunting fees operating in Kajiado District. The controlled area fees received for Kajiado District in 1971 and 1972 are shown in Table III[V], and averaged approximately Shs.260,000 per annum over this period. Controlled area fees have now been replaced by hunting fees but for many species they are the same and hence indicate the order of magnitude of the potential returns to landowners. There is no readily available data on booking fees but if all twenty wildlife management areas were fully booked all year by two hunters at even the resident rate of Shs.5 per day, then this represents another Shs.73,000. Thus, total revenue due to the landowner is approximately Shs.333,000 per annum.

Revenue to the Game Department of the Ministry of Tourism and Wildlife

Hunting revenue retained by the Game Department is composed of licence fees for Full and Fourteen-day licences as shown in Table III[VI], Special Licence fees given in Table III[VII] and Professional Hunters Licence fees. Game Department data to date appear to only exist in very raw form and the Wildlife Management Project is aiming to improve data collection and analysis. However, using data for the period January - April 1974, non resident, full and fourteen day licence fees amounted to Shs.76,000, and assuming that that is a representative period then the total annual revenue would be Shs.228,000. At the

moment it is not possible to give an indication of the revenue from resident licences because it is not feasible to relate the number of bookings to the number of licences. It is reasonable to assume that a non resident will only make one hunting safari per year but residents may go hunting many times in a period of one year. However, revenue from resident licences will be far below that from non resident licences because of the large price discrimination (see Table III[VI]).

Each of the 133 professional hunters operating in Kenya is required to hold a professional hunters licence. This provided an average revenue of Shs.150,000/- per annum to the Game Department in the period 1972/73.

Table III[V] gives an indication of the order of magnitude of revenue from special licence fees in Kajiado District, which amounts to an average of approximately Shs.133,000 per annum during the period 1971/72. In fact the figure per animal will be greater than the licence fee because a special licence is purchased before hunting and one animal is not necessarily shot for each licence that is purchased. Hence, Game Department revenue from the sale of the various hunting licences is well in excess of Shs.500,000 per annum.

Contribution to the Kenyan Economy

One of the most significant features of the hunting industry is its ability to earn foreign exchange with little demand on the infrastructure. In 1972 the professional hunting industry earned Shs.40.1 million in foreign exchange. This represents 7.3% of the total revenue accruing to the tourist sector but it only accounts for 1% of the total visitors. In other words each overseas hunter spends, on average, over Shs.60,000 per trip. This expenditure is made in several ways. Firstly, the overseas hunter may pay up to Shs.2,000 per day to a professional hunter. Implicit in this payment is the professional hunter's services, the wages of trackers, skinners and camp staff, insurances, the

provision of transport, hunting equipment, camping facilities and food. Secondly, he is required to purchase hunting and special licences and also pay hunting fees. Thirdly, there is expenditure on taxidermy (see Table III[VIII]). Finally, some time will probably be spent in Nairobi, at the Coast, or elsewhere after the safari.

Since hunting is dependent on other industries it had a multiplier effect. The taxidermy industry is very dependant on the state of the hunting sector. A thriving hunting industry boosts those sectors which provide hunting equipment such as camping gear, vehicles and particularly guns and ammunition. In this way a growing hunting industry can increase employment opportunities as well as the obvious direct employment potential for trackers, skinners and camp staff. Since there are obvious advantages of employing local people as trackers this provides a form of rural employment in some of the more under-developed areas.

CROPPING

A detailed analysis of cropping costs and revenues, and hence the potential revenues has been set out in Appendix III[I]. It should be pointed out that there are still significant technical problems to be overcome before it would be possible to carry out cropping in Kajiado District on a realistic commercial basis.

Returns to Landowner

Since this activity is not being practical in Kajiado District it is only possible to theorise about the flows of revenue both in magnitude and direction. Potential returns based on the analysis in Appendix III[I] are given in Tables III[IX], III[X], and III[XIII]. Tables III[IX] and III[X] give the potential net returns for two cases.

Case I is purely theoretical in that it represents 10% of the potentially profitable croppable animals. In practice, due to technical and market limitations and the assumption that this should be a sustained yield, Case II in which 5,000 animals are cropped, probably represents the realistic maximum. Figures excluding zebra from the crop are given because informed sources of information estimate that the potential offtake of zebra is already more than used up through legal and illegal hunting. Returns to land and landowners are given for the total area and total number of families and for 50% of these figures. This is because cropping is only possible in the plains area and thus cropping revenue is really only due to those areas which support the wildlife population which has been cropped. Case II, without zebra, with the cropper retaining half the net revenue would provide each family living in the rangeland area of Kajiado District with an after interest annual income of Shs.24.13. However, for the reasons set out above, it is probable that half the number of families would receive twice this amount.

Returns to the Game Department of the Ministry of Tourism and Wildlife

As this activity is not established there are no returns to the Game Department. The Game Department may decide to levy some kind of tax or licence but in effect this would just lower the potential returns to the landowner.

Contribution to the Kenyan Economy

Total net revenues are given in Table III[F] which shows that Case II without zebra yields a net revenue of approximately Shs. 673,384 after the deduction of variable costs. Variable cropping costs are approximately Shs.416,000 and hence the total value of this activity amounts to Shs.1,274,000. This activity could contribute to the overall economy in three ways. Firstly, it

provides a source of meat. This is particularly significant as Kenya is expanding its beef exports and game meat may help to fill any vacuum in the home market. Secondly, it provides employment. Thirdly, the export of trophies represents foreign exchange earnings.

LIVE CAPTURE

From the Ministry of Tourism and Wildlife figures available it would appear that live capture is only carried out on a small scale relative to the offtake by hunting as shown below.

Value to the Landowner

On private land the sale of an animal for capture is a matter for private negotiation between the trapper and the landowner, and therefore varies between cases. In Kajiado District where the Wildlife Management Project is retaining some control in the newly adjudicated areas it may decide to transfer the Game Department capture fees back to the landowners. (see Table III[XI]).

Value to the Game Department of the Ministry of Tourism and Wildlife

Capture fees payable to the Game Department are set out in Table III[XI]. The Game Department estimates that during the period 1972/73 its average revenue per annum, from the sale of capture permits for the whole of Kenya amounted to Shs.100,000.

Contribution to the Kenyan Economy

Contribution on a per animal basis is considerable although as stated before, this activity is only on a relatively small scale. The prices being quoted by a leading trapper in Kenya are given in Table III[XII], and reflect the value of each animal captured alive. Since most captured animals are exported, this represents foreign exchange.

SECTION III

A comparison of the Potential Revenues from the Major forms of Wildlife Utilisation in Kajiado District

This Section is concerned with a comparison of the revenue earned by the four major wildlife utilisation activities namely tourism, hunting, cropping and live capture. Examination of the total revenue from each activity is necessary for a meaningful discussion of the financial incentives for the landowner to maintain wildlife on his land and the overall contribution to the National Economy. On the other hand a look at the return per animal for each activity, both to the landowner and in terms of value to the National Economy indicates the areas where maximum gain can be gained from minimum expansion.

Contribution to the Kenyan Economy

Cropping differs from hunting, capture and tourism in that the majority of the revenue accruing to the latter activities are in foreign exchange earnings whereas meat from cropping is mainly for consumption within Kenya although hides and horns may be manufactured for export. Industries which earn foreign exchange are important in any economy especially in a developing country like Kenya which in 1974 was suffering from a balance of trade deficit of Shs.1000 million. However, any foreign exchange earnings from hunting and capture are overshadowed by earnings from the wildlife viewing activity.

Nairobi and Amboseli National Parks are two of Kenya's most popular national parks in terms of visitor numbers. (Both parks, especially Nairobi, are in close proximity to Nairobi town and Amboseli has the additional attraction of Kilimanjaro as well as forming a circuit with Tsavo West National Park). It has already been estimated in this Chapter that the value of wildlife viewing by non residents in these two areas was over Shs.20.3 million in

1973 and the value of hunting by non residents was Shs.7.1 million. Hence, the total foreign exchange earning by hunting and viewing amounted to Shs.27.4 million or 5.6% of the total national value of tourism in Kenya during 1973. The hunting sector is of particular significance because it makes little demand on infrastructure and yet is able to earn foreign exchange.

Since the value of the wildlife viewing activity is greater than other forms of wildlife utilisation it has a greater influence on the internal economy and stimulates those sectors which provide goods and services for the tourist industry. The creation of employment opportunities outside agriculture is particularly important for a developing country such as Kenya which is striving for economic development.

Landowner Returns

With the advent of land adjudication in Kajiado District the form of wildlife utilisation or its destruction lies much more in the hands of the landowner (legally) than under the traditional system where the Game Department of the Ministry of Tourism and Wildlife was responsible for all game management. It is interesting, therefore, to compare the potential revenues accruing to the landowner from the various forms of wildlife utilisation since it is this which will determine how he utilises the wildlife population existing on his land, or indeed, whether he decides to maintain it at all.

At the moment no revenue flows from the tourist sector to the Kajiado landowner. Any transfer payment in the future would need to be based on some meaningful criteria, as yet undefined, and attempt to equate public and private returns from tourism. The only way in which landowners might actively capture some of the tourist revenue as a direct result of supporting game on their land, would be through the construction of lodges, bandas and viewing facilities. Likewise, at the moment none of the

revenue from live capture is being channelled back to the landowners in Kajiado District.

It is significant to discuss the total landowner returns from hunting and cropping. Although no revenues from hunting have been distributed to the landowners in Kajiado District it is anticipated that hunting and booking fees will be returned to them and were estimated to amount to Shs.350,000/- earlier in this Chapter. From Table III[XII] net revenue from cropping, assuming that Case II without zebra is the most likely situation, amounts to Shs.673,384/- including interest. If the cropper retained half of this in the form of profit then net returns to the landowner would be approximately Shs.300,000/- after interest. In other words,, in terms of the anticipated total net returns there is little difference between hunting or cropping as far as the landowner is concerned. Total revenue from capture is below these figures because as discussed previously it is on a small scale.

On the other hand, if the value of cropping, hunting and capture is examined on a per animal basis, a completely different picture emerges. Table III[XIV] sets out the licence fees for hunting and capture, and the net profit from cropping the technically croppable species. It can be seen that the hunter and the capturer pay the same in licence fees except for wildebeest and kongoni for which the capturer pays 50% more. Except for wildebeest these licence fees are in excess of the net revenue from cropping and it should be remembered that in addition the hunter has to buy a hunting licence and pay booking fees. Therefore, on a per animal basis the value of an animal hunted or captured is much greater than an animal cropped, especially as the former activities are able to earn foreign exchange. However, from the point of view of the Kajiado landowner, at the moment he can only anticipate income from

hunting (hunting and booking fees returned to him from the Game Department of the Ministry of Tourism and Wildlife) and from cropping. As discussed above, the potential total returns to the landowner from these two activities are approximately the same after the cropper has deducted his share of the profits. Hence it is likely that the landowner will be indifferent between the two activities. This point is of great significance because it indicates that public returns are not being reflected to the landowner and so the pattern of wildlife utilisation which the landowner will adopt will not lead to an optimum pattern as far as the national economy is concerned.

These total revenues from cropping and hunting are small when divided between the families in Kajiado District. There are about 12,500 families there which gives an average return after interest of approximately Shs.24.13 per annum from cropping under Case II without zebra. Revenue from hunting will also be of the same order. It is highly questionable whether this would be adequate incentive to retain wildlife in the traditional subsistence economy, and, without doubt, would be inadequate in a commercial economy. Even if this figure is doubled according to the argument that these activities are only possible in half the area of Kajiado District the picture still does not appear favourable. On the other hand the situation is more promising if considered on a ranch basis. On average one hundred and forty families live on each ranch, therefore, if revenue is split between the total area of Kajiado District the average income is Shs.3378/- per annum and it is arguable on the grounds set out above that this revenue is attributable to only half the ranches giving an average revenue of Shs.6756/- per annum. At subsistence level such a sum may well appear to be an adequate incentive to maintain wildlife but as commercial cattle ranching develops revenue from that industry will increase to the point where it overshadows wildlife revenue. It is also important to note that the disadvantages of maintaining cattle and game in the

same area (e.g. disease transmission, damage to fences and other constructions) become less tolerable as cattle ranching moves from the traditional set up to a more developed and sophisticated organisation.

CONCLUSION

The major point which emerges from the above discussion, and which cannot be too heavily emphasised, is that the flows of revenue to the landowner for maintaining wildlife on his land are inadequate and undeveloped. In spite of the value of the two main forms of utilisation which exist in Kajiado District (tourism and hunting) the existing economic structure of these industries does not allow the landowner to adequately financially benefit even though he is supporting the foundations of these industries on his land. In this situation it is to his advantage to replace wildlife by livestock and the land adjudication process being carried out in Kajiado District will enable him to do this. It is necessary therefore, to ensure that there is a flow of revenue back to the landowner from the wildlife utilisation activities being carried out in Kajiado District. Although it is planned to return the hunting and booking fees to the landowner, there is no mechanism whereby any of the revenue from wildlife viewing might be returned even though this is, by far, the most economically significant form of utilisation.

TABLE III[I]. THE INFLUENCE OF VARIOUS COMBINATIONS OF VARIABLES EFFECTING POPULATION STRUCTURE OF ANIMALS GROWTH IN POPULATION SIZE

Survival rate of animals over one year old	Calf Survival Rate	Fraction of breeding females calving per annum	Average number of young in each parturition	Sex Ratio	Age of first parturition	% breeding females (1)	Potential increase in population size (2)	Net growth rate of population size (3)	Survival rate of animals over one year old such that population size remains constant (4)	Removal rate (5)
s	k	c	y	j	p	f	i	r	s_1	R
0.95	0.8	1	1	0.5	1	41.67	41.67	30.00	0.50	31.25
0.98	0.8	1	1	0.5	1	41.67	41.67	32.00	-	-
0.9	0.8	1	1	0.5	1	41.67	41.67	26.67	-	-
0.9	0.9	1	1	0.5	1	40.82	40.82	33.57	0.42	35.55
0.9	0.7	1	1	0.5	1	42.55	42.55	26.28	0.58	27.08
0.9	0.7	1.3	1	0.5	1	37.45	48.69	35.90	0.36	35.85
0.9	0.7	0.9	1	0.5	1	43.29	38.96	27.73	0.55	29.41
0.9	0.7	0.9	1.1	0.5	1	40.16	44.18	32.11	0.45	32.93
0.9	0.7	0.9	1.1	0.4	1	43.48	43.48	31.52	0.41	32.46
0.9	0.7	0.9	1.1	0.6	1	40.00	40.00	28.60	0.53	30.12
0.9	0.7	0.9	1.1	0.6	2	31.45	31.45	21.42	0.65	25.40
0.95	0.8	0.8	1	0.5	2	35.16	28.13	18.63	0.70	22.52
0.98	0.8	0.8	1	0.5	2	35.04	28.03	20.87	-	-
0.9	0.8	0.8	1	0.5	2	35.36	28.24	14.89	-	-
0.9	0.9	0.8	1	0.5	2	33.76	27.01	20.52	0.66	25.03
0.9	0.7	0.8	1	0.5	2	36.68	29.35	16.57	0.73	19.96
0.9	0.7	0.9	1	0.5	2	33.20	29.88	20.10	0.67	24.02
0.9	0.7	0.7	1	0.5	2	37.37	26.16	16.97	0.73	20.36
0.9	0.7	0.7	1.1	0.5	2	33.58	29.55	19.82	0.68	23.73
0.9	0.7	0.7	1.1	0.4	2	36.44	29.15	19.49	0.68	23.40
0.9	0.7	0.7	1.1	0.6	2	33.97	27.17	17.83	0.71	21.70
0.9	0.7	0.7	1.1	0.6	3	29.10	23.28	14.55	0.75	19.76

TABLE III[I] (continued)

s	k	c	y	j	p	f	i	r	s_1	R
0.95	0.8	0.7	1	0.5	3	31.30	21.91	13.41	0.77	18.37
0.98	0.8	0.7	1	0.5	3	30.98	21.69	15.70	-	-
0.9	0.8	0.7	1	0.5	3	31.84	22.29	9.61	-	-
0.9	0.9	0.7	1	0.5	3	29.74	20.82	14.67	0.76	20.23
0.9	0.7	0.7	1	0.5	3	33.04	23.13	12.00	0.80	16.44
0.9	0.7	0.6	1	0.5	3	33.87	20.32	12.07	0.79	16.81
0.9	0.7	0.8	1	0.5	3	29.10	23.28	14.55	0.75	19.76
0.9	0.9	0.8	1.1	0.5	3	29.73	22.89	14.23	0.76	19.36
0.9	0.7	0.8	1.1	0.4	3	32.31	22.62	14.00	0.76	19.07
0.9	0.7	0.8	1.1	0.6	4	30.35	21.25	12.85	0.78	17.70

(1) $$f = \frac{200}{(cy\,[1+k+k\,(1+s)(s^0+\ldots+s^{p-2})]+2+2j)}$$

when p is less than 2 let $(s^0+\ldots+s^{p-2}) = 0$

(2) $$i = cyf = \frac{200\,cy}{(cy\,[1+k+k\,(1+s)(s^0+\ldots+s^{p-2})]+2+2j)}$$

(3) $$r = cyfk\,(2-s) + 100\,(s-1) = \frac{200\,cyk\,(2-s)}{(cy\,[1+k+k\,(1+s)(s^0+\ldots+s^{p-2})]+2+2j)} + 100\,(s-1)$$

(4) when p=1 $$s_1 = \frac{2 + 2i + cr - 3\,cyk}{2 + 2j + cy - cyk}$$

when p=2

$$s_1 = \frac{-2-2j-cy-cyk + \sqrt{(2+2j+cy+cyk)^2+4cyk(cy+2cyk+2j+2)}}{2\,cyk}$$

when p=3 s_1 is determined by trial and error using a computer.

(5) $$R = \frac{100\,(1-s_1)}{(cy\,[1+k+k\,(1+s_1^{p-2})(s_1^0+\ldots+s_1^{p-2})]+2+2j)}$$

* Discrepancies due to rounding.

TABLE III[II]. RELATIONSHIP BETWEEN SEX RATIO (i), POPULATION RATE (r) AND REMOVAL RATE (R).

Value of i	Value of r when s = 0.9 1/*	Value of R 2/*
when p = 1 k = 0.8 c = 1 y = 1		
0.5	30.0	31.25
0.7	27.3	29.0
0.9	25.0	27.1
1.1	23.0	25.5
1.3	21.2	24.0
1.5	19.7	22.6
when p = 2 k = 0.8 c = 0.8 y = 1		
0.5	18.6	22.5
0.7	17.1	21.0
0.9	15.7	19.6
1.1	14.5	18.4
1.3	13.4	17.4
1.5	12.5	16.5
when p = 3 k = 0.8 c = 0.7 y = 1		
0.5	13.4	18.4
0.7	12.3	17.1
0.9	11.4	16.0
1.1	10.5	15.1
1.3	9.7	14.2
1.5	9.0	13.5

1/ $$r = \frac{200\, cyk\,(2-c)}{(cy\,[1+k+k\,(1+c)(s^0+\ldots+s^{p-2})]^{2+2j})} + 100\,(s-1)$$

2/ $$R = \frac{100\,(1-s_1)\,[cyk\,(1+s_1)(s_1^0+\ldots+s_1^{p-2})+2+2j]}{(cy\,[1+k+k\,(1+s_1^{p-2})(s_1^0+\ldots+s_1^{p-2}]^{+2+2j})}$$

* Discrepancies due to rounding.

TABLE III[III]. HUNTING FEES *

Hunting Fees for Animals Killed

	K.Shs.		K.Shs
Dikdik	30	Monkey, blue	60
Duiker, Grey	60	Monkey, patas	100
Gazelle, Grant's	40	Monkey, putty nose	100
Gazelle, Thomson's	40	Monkey, colobus	100
Hartebeeste, Coke's	100	Oryx, fr. eared	400
Oribi	40	Ostrich	200
Reedbuck, Bohor's	40	Roadbuck, Chanler's	80
Steinbok	40	Rhinoceros	5000
Warthog	40	Suni	60
Wildebeest	50	Topi	360
Buffalo	200	Waterbuck, Common	100
Ruckbuck	60	Waterbuck, Defassa	100
Duiker, bl.fr.	60	Zebra, Common	450
Duiker, blue	60		
Duiker, red	60		
Eland	400		
Elephant	1/		
Geronuk	500		
Giraffe	1500		
Impala	100		
Klipspringer	120		
Kudu, Greater	1000		
Kudu, Lesser	400		
Leopard - male	2000		
Lion	1200		

1/ (a) When total weight of both tusks is less than 70 kg: Shs.60 per kg.

(b) When total weight of both tusks is less than 90 kg: Shs.90 per kg.

(c) When total weight of both tusks is 90 kg or more: Shs.150 per kg.

* Payable to the Game Department of the Ministry of Tourism and Wildlife.

TABLE III[IV]. COMPARISON OF PRIVATE LAND FEES AND HUNTING FEES

Species	Private Land Fee 1/ Shs.	Hunting Fee 2/ Shs.
Buffalo	515	200
Bushbuck	215	60
Dikdik	110	30
Duiker	110	60
Eland	820	400
Grant's Gazelle	110	40
Thomson's Gazelle	110	40
Gerenuk	1035	500
Giraffe	3070	1500
Impala	215	100
Klipspringer	250	120
Oryx	820	400
Ostrich	405	200
Reedbuck	215	40
Steinbok	110	40
Suni	155	60
Warthog	215	40
Waterbuck	305	100
Zebra - Common	515	450

1/ Private land fees quoted by a safari operator in Nairobi in 1973.

2/ Hunting fees for Kajiado District payable to the Game Department of the Ministry of Tourism and Wildlife - as introduced in January 1974.

TABLE III[V]. SPECIAL LICENCE AND CONTROLLED AREA FEE REVENUES EARNED IN KAJIADO DISTRICT 1971/1972.

Species	1971 No.Shot	1971 Special Licence 1/ fees revenue (shs)	1971 Controlled area 2/ fees revenue (shs)	1972 No.Shot	1972 Special Licence 1/ fees revenue (shs)	1972 Controlled area 2/ fees revenue (shs)
Buffalo	33	3,300	6,600	61	6,100	12,200
Duskbuck	8	240	480	6	180	360
Dikdik	30	-	900	36	-	1,080
Duker	3	90	180	4	120	240
Eland	31	6,200	2,400	49	9,800	19,500
Elephant	22	44,000	38,500 3/	27	54,000	47,250
Gazelle - Grant's	264	-	10,560	345	-	13,800
- Thomson's	98	-	3,920	139	-	5,560
Gerenuk	37	9,250	18,500	8	2,000	4,000
Giraffe	2	1,500	3,000	2	1,500	3,000
Hartebeest	63	-	6,300	124	-	12,400
Impala	161	8,050	16,100	176	8,800	17,600
Klipspringer	2	120	240	6	360	720
Kudu, Lesser	9	1,800	3,600	1	200	400
Leopard	9	9,000	27,000 4/	18	18,000	54,000
Lion	16	9,600	19,200	19	11,400	22,800
Oryx	56	11,200	22,400	41	8,200	16,400
Ostrich	8	800	1,600	27	2,700	5,400
Reedbuck	17	-	680	9	-	360
Steinbok	15	-	600	21	-	840
Warthog	42	-	1,680	73	-	2,920
Waterbuck	31	1,550	3,100	14	700	1,400
Wildebeest	158	-	7,900	211	-	10,550
Zebra	309	15,450	30,900	390	19,500	39,000
TOTAL	1,424	122,150 5/	236,340	1,807	143,560	291,880

* Footnotes on next page

TABLE III^{V} (continued)

1/ See Table III^{VII}.

2/ Hunting fees replaced Controlled Area Fees in 1974 but for most species they are the same, see Table III^{III}.

3/ Controlled area fees are: (a) 10/- per kg if total weight of tusks is less than 70 kg. (b) 20/- per kg if total weight of tusks is 70 kg but less than 90 kg. (c) 30/- per kg if total weight of tusks is equal to or more than 90 kg. Therefore an arbitrary controlled area fee of Shs.1,750 per elephant has been used.

4/ Male: Shs.2,000, female: Shs.4,000. Therefore an average of Shs.3,000 per leopard has been taken.

5/ Special licence fees revenue is greater than this because an animal is not necessarily shot for every licence bought.

TABLE III[VI]. Hunting Licence Fees.*

Full Licence	Fee (K.Shs.)
Class A - (Visitors)	1,500/-
Class B - Residents who have been in the country two years or less	500/-
Class C - Residents who have been in the country longer than two years but are not citizens	250/-
Class D - Resident citizens	100/-
14-day Licence	
Class A - (Visitors)	500/-
Class B - (Residents)	50/-
Private Land Licence 1/	
Class A - Non-residents	1,000/-
Class B - Any resident	250/-
Employees licence	50/-
Bird licence Visitors and residents	60/-

1/ All except a "Private Land Licence" may be validated for hunting in Kajiado District but must be accompanied by a Chief Game Warden's Permit.

* Payable to the Game Department of the Ministry of Tourism and Wildlife.

TABLE III[VII]. SPECIAL LICENCE FEES*

Animals Permitted by Special Licences

Animals which may be hunted and killed under Special Licence and the number of Special Licences which may be issued to a holder of a Full Licence. (As stated in the Fourth Schedule of the Wild Animals Protection Act).

Species	No. of Special Licences which may be issued to a holder of a Full Licence	Cost of Licence
		Shs.
Bongo	1	500
Buffalo	4	100
Bushbuck	2	30
Crocodile	3	75
Duiker, Blue	1	30
Duiker, Foster's or Hooks Black Fronted	1	30
Duiker, Red or Harvey's	1	30
Eland	1	200
Elephant	1	5000
Gerenuk	1	250
Giant Forest Hog	1	75
Giraffe, Common and Reticulated	1	750
Impala	2	50
Klipspringer	1	60
Kudu, Greater	1	500
Kudu, Lesser	1	200
Leopard	1	1000
Lion, Masai	1	600
Lion	1	300
Monkey, Blue or Sykes	1	30
Monkey, Putty Nosed	1	50
Monkey, Red or Pattas	1	50
Monkey, Black and White Colobus	1	60
Oryx, Fringe Eared	1	200
Oryx, Beisa	1	200
Ostrich	1	100
Reedbuck, Chanler's Mountain	1	40
Rhinoceros	1	2500
Suni	1	30
Tepi	1	180
Waterbuck, Common	1	50
Waterbuck, Defassa	1	50
Zebra, Common or Burchell's	3	150
Zebra, Grevy's	1	300

* Payable to the Game Department of the Ministry of Tourism and Wildlife.

TABLE III[VIII]. TAXIDERMIST PRICE LIST*

Species	Head Mounts	Dress Body Skin	Bleach Skull Only	Full Mount
Baboon	550	90	75	2100
Badger	250	70	50	980
Bongo	1550	250	130	10350
Buffalo - (Long Hook)	1850	-	175	17250
Buffalo - (Short Hook)	1750	-	-	-
Bush/Reedbuck	700	100	85	4500
Cheetah	800	140	95	3500
Kob, Gerenuk, Grant, Impala, Lesser Kudu,	800	100	90	4500
Dik Dik, Suni, Duiker, Oribi,	350	50	45	1000
Steinbuck	400	70	50	1500
Eland	1550	350	120	17250
Giant Forest Hog	900	-	160	8000
Giraffe	4200	1500	-	8000
Greater Kudu	1500	230	130	10350
Hartebeest	900	140	105	7000
Hippopotamus	5000	-	515	-
Hyena	800	130	105	2900
Jackal	400	70	65	1100
Klipspringer	550	70	50	1850
Leopard	850	160	130	4500
Lion & Lioness	1150	230	145	6325
Monkey, Sykes	850	60	160	1800
Colobus	325	70	70	1800
Oryx	1050	150	105	9775
Roan & Sable	1150	175	130	10350
Rhino	2000	1300	290	-
Serval Cat	250	90	65	1050
Thomson's Gazelle	700	80	90	3500
Topi	900	140	105	6900
Warthog	900	-	160	5750
Waterbuck	1050	150	105	9200
Wild Dog	500	130	90	1700
Wildebeest	1050	140	130	9775
Zebra - common	900	240	145	9775
Zebra - Grevy's	1050	260	155	9775

* Figures provided by Zimmerman, Nairobi. These are the increased prices introduced in March 1974 which are approximately 25% higher than the pre-March prices.

TABLE III[VIII] (continued)

Tusk and Horn Novelties (Warthog, Thomson's and Grant's Gazelle)

Ice pick	Shs.135	Can opener	Shs.110
Cheese knife	Shs.135	Dinner gong	Shs.600
Bar knife	Shs.135	Cigar cutter	Shs.245
Bottle opener	Shs.100	Cocktail spoon	Shs.185
Corkscrew	Shs.100	Beer mug	Shs.420
Paper knife	Shs.100		
Candlestick	Shs.325		

Foot Mounts

(a)	Antelope, Buffalo, Eland and Zebra:	
	Ashtrays (wood)	Shs.250
	Bookends	Shs.350
	Candlesticks (wood fitments)	Shs.260
	Cigarette Box	Shs.290
	Cigarette Lighter	Shs.300
	Table Lamp (triple feet with wood fitments)	Shs.640
	Carving Set	Shs.350
	Gun Rack	Shs.270
(b)	Lion and Leopard:	
	Leopard Foot ashtray (stone)	Shs.175
	Lion Foot ashtray (chrome)	Shs.450
	Lion Foot lampstand (chrome)	Shs.525
(c)	Rhino and Hippo:	
	Ashtray (stone)	Shs.250
	Cigarette box	Shs.210
	Door stop	Shs.250
(d)	Elephant:	
	Cocktail table	Shs.475
	Cocktail tray	Shs.375
	Stool	Shs.400
	Waste basket	Shs.300
	Ice box	Shs.800
	As mounts for tusks	Shs.1100
	Bar stool	Shs.700
	Decanter stand	Shs.600

Elephant Tusk Mounts

Tusks cleaned and washed and polished	Shs.350
Elephant tusk dinner gong	Shs.3200
Mounted on metal bases	Shs.2350
Standard lamp single tusk (chrome)	Shs.1400
For wall hanging with chrome	
Caps, Chain and sleeves (over 50 lbs)	Shs.2050
Nerve end capped only in Chrome (over 50 lbs)	Shs. 900

TABLE III[IX]. NET REVENUES FROM CROPPING IN KAJIADO DISTRICT (excluding storage and distribution costs)*

	Sale price of meat (shs/kg)				
CASE I	3/50	4/50	5/-	5/50	6/-
Including zebra					
Net revenue including interest (shs)	3,401,468	4,311,468	4,766,468	5,221,468	5,676,468
Net revenue excluding interest (shs)	3,317,280	4,227,280	4,682,280	5,137,280	5,592,280
Excluding zebra					
Net revenue including interest (shs)	1,692,548	2,302,548	2,607,548	2,912,548	3,217,548
Net revenue excluding interest (shs)	1,608,360	2,218,360	2,523,360	2,828,360	3,133,360
CASE II					
Including zebra					
Net revenue including interest (shs)	1,375,077	1,788,327	1,994,952	2,162,577	2,408,202
Net revenue excluding interest (shs)	1,304,952	1,718,202	1,924,827	2,092,452	2,338,077
Excluding zebra					
Net revenue including interest (shs)	673,389	956,639	1,098,264	1,239,889	1,381,514
Net revenue excluding interest (shs)	663,264	886,514	1,028,139	1,169,764	1,381,514

CASE I: 10,700 animals are cropped p.a. (6,000 wildebeest, 500 eland, 1,200 kongoni, 3,000 zebra) at a cropping cost of 80.36 shs. per animal unit (Shs.80.36 for wildebeest, kongoni, and zebra and Shs.160.72 for eland). Interest costs are Shs.84,187.5 p.a. 10,700 represents 10% of the wildebeest, kongoni, eland and zebra populations in the potentially croppable areas of Kajiado District.

CASE II: 5,000 animals are cropped p.a. (2,800 wildebeest, 235 eland, 525 kongoni, 1,300 zebra) at a croppable cost of Shs.110.24 per animal unit (Shs.110.24 for wildebeest, kongoni and zebra and Shs.220.48 for eland). Interest costs are Shs.70,125 p.a.

* Based on Appendix III[I].

TABLE III[X]. NET REVENUE FROM CROPPING IN KAJIADO DISTRICT

CASE I (as defined in Table III[IX])

	Returns if cropper retains 25% of the net revenue		Returns if cropper retains 50% of the net revenue	
	Excluding Zebra	Including Zebra	Excluding Zebra	Including Zebra
Total Net Revenue - incl. zebra 3,401,468 (net of interest 3,317,280)				
- excl. zebra 1,692,548 (net of interest 1,608,360)				
Total net revenue after cropper's profit - incl. interest	1,269,411	2,551,101	846,274	1,700,734
- excl. interest	1,206,270	2,487,960	804,180	1,658,640
Returns to Land				
Net revenue ÷ 2 million hectares incl. interest	0.63	1.28	0.42	0.85
excl. interest	0.60	1.24	0.40	0.83
Net revenue ÷ 1 million hectares incl. interest	1.27	2.55	0.85	1.70
excl. interest	1.21	2.49	0.80	1.66
Returns to Landowner				
Net revenue ÷ 12,500 - incl. interest	101.55	204.09	67.70	136.06
- excl. interest	96.50	199.04	64.33	132.69
Net revenue ÷ 6,250 - incl. interest	203.11	408.18	135.40	272.12
- excl. interest	193.00	398.07	128.67	265.38

TABLE III[X] (continued). NET REVENUE FROM CROPPING IN KAJIADO DISTRICT*

CASE II (as defined in Table III[IX])

	Returns if cropper retains 25% of the net revenue		Returns if cropper retains 50% of the net revenue	
	Excluding Zebra	Including Zebra	Excluding Zebra	Including Zebra
Total Net Revenue – incl. zebra 1,375,077 (net of interest 1,304,952) – excl. zebra 673,384 (net of interest 603,264)				
Total net revenue after cropper's profit – incl. interest	505,042	1,031,308	336,695	687,539
– excl. interest	452,448	978,714	301,632	652,476
Returns to Land				
Net revenue ÷ 2 million hectares incl. interest	0.25	0.52	0.17	0.34
excl. interest	0.23	0.49	0.15	0.33
Net revenue ÷ 1 million hectares incl. interest	0.51	1.08	0.34	0.69
excl. interest	0.45	0.98	0.30	0.65
Returns to Landowner				
Net revenue ÷ 12,500 – incl..interest	40.40	82.50	26.94	55.00
– excl. interest	36.20	78.30	24.13	52.20
Net revenue ÷ 6,250 – incl. interest	80.81	165.01	53.87	110.01
– excl. interest	72,40	156.59	48.26	104.40

N.B. 1. In cases where interest is deducted the proportion of returns retained by cropper is after interest.

2. It may not be feasible to crop zebra due to existing pressure from legal and illegal hunting.

3. Costs only include operating costs of the cropping exercise.

4. Net revenue does not include any element of wastage i.e. maximum total revenue figures.

5. Net revenue is based on sale price of Shs.3/50 per kg for meat.

* Based on Appendix III[I].

TABLE III[XI]. LIVE CAPTURE FEES*

	Shs
Buffalo	300
Bushbuck	90
Crocodile	225
Dikdik	45
Duiker - Grey	90
Duiker - Blue	90
Duiker - Red	90
Duiker - Foster's or Hook's	90
Eland	600
Elephant	2500
Grant's Gazelle	60
Thomson's Gazelle	60
Gerenuk	750
Giant Forest Hog	225
Giraffe - Common or Reticulated	1500
Coke's Hartebeest	150
Impala	180
Klipspringer	180
Kudu - Greater	1500
Kudu - Lesser	600
Leopard - male	3000
Leopard - female	5000
Lion - Masai	1800
Lion - Other	900
Oribi	60
Oryx - Beisa or Fringe eared	600
Ostrich	300
Reedbuck - Chanler's Mountain	120
Reedbuck - Bohor's	60
Rhinoceros	7500
Steinbok	60
Suni	80
Topi	540
Warthog	60
Waterbuck - Common & Defassa	150
Wildebeest	75
Zebra - Common	600
African Wild Cat	40
Baboon	20
Bush pig	20
Civet cat	100
Genet cat	100
Hyaena	40
Jackal	40
Polecat, zorilla and striped weasels	40
Spring Hares	40
Squirrels	20
Tortoise	40

* Payable to the Game Department of the Ministry of Tourism and Wildlife.

TABLE XII[XII]. SALE PRICE OF LIVE ANIMALS*

	Shs
Elephant (Male)	13,500
Elephant (Female)	17,500
Rhinoceros (Black)	30,500
Hippopotamus	15,000
Buffalo	3,700
Giraffe (Masai)	8,000
Giraffe (Reticulated)	8,700
Giraffe (Rothschilds)	9,000
Eland	3,400
Zebra (Grants)	2,700
Zebra (Grevy)	8,000
Waterbuck (Ellipsiprymnus)	4,200
Waterbuck (Defassa)	4,200
Hartebeest (Coke's)(Kongoni)	6,000
Hartebeest (Jacksons)	7,000
Topi	8,000
Wildebeest (Gnu)	2,700
Oryx (Beisa)	4,400
Oryx (Callotis)(Fringe eared)	4,400
Lesser Kudu	8,000
Uganda Kob	5,000
Impala	2,000
Gerenuk	8,000
Grant's gazelle	2,200
Thomsen's gazelle	1,400
Bushbuck	4,200
Reedbuck	2,400
Steinbuck	1,500
Duiker	1,100
Dikdik	1,000
Bush Pig	1,300
Warthog	1,100
Antbear	3,000
Lynx (Caracal)	1,500
Serval Cat	1,500
Hyaena (Spotted)	1,100
Jackal (Black-backed)	600
Bat-eared Fox	1,000
Genet Cats	245
Mongoose (White-tailed)	350
African Spring Hare	300

All prices are FOB Mombasa, or Nairobi Airport, crated with food for the calculated normal journey.

Quarantine fees and/or any clinical tests required, are extra.

* Prices quoted in 1973 by animal trapper based in Nairobi.

TABLE III[XIII]. NET REVENUES FROM CROPPING ON A PER ANIMAL BASIS

Species	One animal expressed as a fraction of one animal unit 1/	Cropping Costs 2/ 1 a.u. = Shs.150	Cropping Revenue (Shs) 3/ (meat + skins = total)	Net Revenue (Shs) (10% wastage)
Wildebeest	1	150	262.5 + 30 = 292.5 4/	142.5 (116.25)
Kongoni	1	150	175 + 20 = 195	45 (25.5)
Eland	2	300	700 + 25 = 725	425 (352.5)
Impala	2/3	100	70 + 25 = 95	-5 (-14.5)
Grant's Gazelle	2/3	100	70 + 35 = 105	5 (- 5.5)
Thomson's Gazelle	⅓	75	31.5 + 25 = 56.5	-18.5 (-24.15)
Zebra	1	150	350 + 300 = 650	500 (435)

1/ Based on average weight and adjusted according to interpolation.

2/ Average cost taken from Table C of Appendix III[I].

3/ Assumed price of meat is Shs.3/50 per kg on average.

Assumed average carcass weights:

Wildebeest	85 kg	Grant's Gazelle	20 kg
Kongoni	60 kg	Thomson's Gazelle	9 kg
Eland	200 kg	Zebra	100 kg
Impala	20 kg		

4/ Little demand for wildebeest skins therefore the production of a large number from a cropping operation would force prices down to the equivalent of cowhide prices at Shs.20/- per skin.

TABLE III[XIV]. COMPARISON OF THE POTENTIAL REVENUE FROM HUNTING, CROPPING AND CAPTURE ON A PER ANIMAL BASIS

Species	Special Licence Fees (shs)	Hunting Fees (Shs)	Sum of Special Licence and Hunting Fees (Shs)	Live Capture Fees (shs)	Net Revenue + from cropping (max) (shs)
Eland	200	400	600	600	425
Grant's Gazelle	-	40	40	60	5
Thomson's Gazelle	-	40	40	60	-18.5
Wildebeest	-	50	50	75	142.5
Kongoni	-	100	100	150	45
Impala	50	100	150	150	-5
Zebra	150	450	600	600	500

+ from Table III[XIII].

APPENDIX III[I]. AN ANALYSIS OF GAME CROPPING COSTS AND REVENUES IN THE KAJIADO DISTRICT OF KENYA.

I INTRODUCTION

This appendix is concerned with a detailed analysis of the costs and revenues which would face an organisation carrying out game cropping operations. The data used has been collected by the Wildlife Management Project in its previous cropping operations. Implicit in these calculations are the potential revenues which Kajiado District as a whole would derive from cropping.

The analysis is set out as follows:-

Section II briefly describes the cropping operation.

Section III sets out the factors which limit the rate of offtake per day.

Section IV categorises and breaks down the costs incurred in a cropping operation.

Section V summarises the costs and revenues.

II DESCRIPTION OF OPERATIONS

A firm carrying out game cropping may operate in the following way:-

1. The firm operates from a head office in Nairobi.
2. The firm operates in Kajiado District within a radius of 200 km from Nairobi.
3. Method of operation
   a. The equipment is transported from Nairobi in a single journey per vehicle except for the abattoir prime mover which returns to collect the insulated trailer unit.
   b. The mobile abattoir is set up in the selected location.

c. Total setting up time is half a day.

d. Animals are shot by a shooter in a mini-moke in daylight. (To date, this method has been tested on wildebeest only).

e. Animals are collected by five collectors in a pick-up and taken back to the abattoir.

f. Carcasses are processed through the abattoir and inspected.

g. All passed and retained meat is loaded into the insulated van and transported back to Nairobi.

h. After the last load of meat the insulated trailer unit is left in Nairobi and the prime mover returns to collect the abattoir trailer unit.

i. The skins are processed and stored and transported back to Nairobi at the end of the operation.

j. At the end of the operation all vehicles and equipment return to Nairobi in a single journey.

k. Between operations, maintenance and repair of vehicles and equipment is carried out.

4. This analysis does not include marketing or any storage and distribution charges in Nairobi.

5. All field staff are paid on a salaried basis. Even if the number of days spent in the field does not constitute full time employment for field staff it would probably be necessary to retain a permanent rather than casual field staff so that a competent staff is always readily available.

6. It is assumed that the insulated van does not impose a constraint with respect to distance from Nairobi. If the firm operates within a radius of 200 km then

maximum travelling time will be ten hours (400 ÷ 40 kph), plus six hours cooling time in the van plus two hours handling time gives a total of eighteen hours. Thus it should be possible to make a round trip every twenty-four hours. When operating at the limits it may be necessary to provide some storage facilities on site and an extra driver.

These extra costs have not been specifically included but firstly there is an item for miscellaneous costs and secondly the driver of the manager's pick-up (see note in section on factors limiting rate of offtake per day) may take on this extra driving requirement.

7. The costs have been estimated for a kongoni/wildebeest sized animal of 125-250 kg live weight using data which has been collected in previous field operations. If this is termed one animal unit it is possible to express each species as a fraction of an animal unit. For example, one Thomsons Gazelle would be equal to half an animal unit if it takes half the processing time of a wildebeest and half as much space in the insulated van.

8. Assumptions about, and relationships between offtake/day, number of days per operation and total number of days in the field are set out in Table A.

III FACTORS LIMITING RATE OF OFFTAKE PER DAY

As the rate of offtake rises so total costs will increase but certain categories of cost (namely type B, C and D) do not rise proportionately to the change in offtake rate. The way in which staff, vehicle and equipment requirements change as the offtake increases are set out overleaf.

20+ animals/day

Field Staff	1 Shooter
	5 Collectors
	1 Abattoir Foreman
	4 Skinners
	2 Fleshers
	1 Eviscerator
	1 Splitter
	2 Inspectors
	1 Field Clerk
Drivers	1 Prime mover - Abattoir and Insulated trailer
	1 Water tanker
	1 Mini-moke
	3 Pick-ups *
	1 Lorry
Vehicles	1 Water tanker
	1 Mini-moke
	3 Pick-ups
	1 Lorry
Trailers	1 Abattoir unit
	1 Insulated trailer unit
Equipment	Abattoir equipment
	Camping equipment
	Generator
	Compressor
	Miscellaneous equipment

26+ animals/day

Additional Field Staff	2 Skinners
	1 Flesher

* There is a possibility that the number of pick-up drivers may be reduced by one if the manager drove himself all the time. Only two pick-ups are actually needed in field operations - one for collection of carcases and one for dumping offal.

40+	animals/day	
	Additional Field Staff	1 Shooter 5 Collectors 2 Skinners 1 Flesher 1 Eviscerator 1 Splitter 1 Inspector
	Additional Drivers	1 Mini-moke 1 Pick-up
	Additional Vehicles	1 Mini-moke 1 Pick-up
	Additional Equipment	Abattoir extension Abattoir equipment Camping equipment
50+	animals/day	
	Additional Driver	1 Insulated van
	Additional Vehicles	1 Insulated van - trailer unit - prime mover
53+	animals/day	
	Additional Field Staff	1 Flesher
60+	animals/day	
	Additional Field Staff	1 Inspector 2 Skinners
66+	animals/day	
	Additional Field Staff	1 Flesher
80+	animals/day	
	Additional Field Staff	1 Shooter 5 Collectors 2 Skinners 1 Flesher 1 Eviscerator 1 Splitter 1 Inspector 1 Field Clerk 1 Assistant Manager 1 Abattoir Foreman

	Additional Drivers	1 Mini-moke 1 Pick-up 1 Abattoir
	Additional Vehicles	1 Abattoir prime mover 1 Mini-moke 2 Pick-ups
	Additional Trailers	1 Abattoir trailer unit
	Additional Equipment	Abattoir equipment Camping equipment Miscellaneous equipment
93+	animals/day	
	Additional Field Staff	1 Flesher 2 Skinners
100+	animals/day	
	Additional Field Staff	1 Inspector
	Additional Drivers	1 Insulated van
	Additional Trailers	1 Insulated van-unit
106+	animals/day	
	Additional Field Staff	2 Skinners 1 Flesher
	Additional Drivers	1 Water tanker
	Additional Vehicles	1 Water tanker
120+	animals/day	
	Additional Field Staff	1 Shooter 5 Collectors 2 Skinners 1 Flesher 1 Eviscerator 1 Splitter 1 Inspector
	Additional Drivers	1 Mini-moke 1 Pick-up
	Additional Vehicles	1 Mini-moke 1 Pick-up
	Additional Equipment	Abattoir extension Abattoir equipment Camping equipment

133+ animals/day

Additional Field Staff 1 Flesher

140+ animals/day

Additional Field Staff 1 Inspector
2 Skinners

146+ animals/day

Additional Field Staff 1 Flesher

150+ animals/day

Additional Drivers 1 Insulated van

Additional Vehicles 1 Insulated van - prime mover unit

IV DESCRIPTION OF COSTS

A firm carrying out a cropping operation is faced by a wide variety of costs. For the purposes of this analysis it is convenient to divide them into six major types which are listed below. In each category the value of each item of cost is given and this is followed in Section IVb by a breakdown of how these costs vary according to the offtake rate per day.

a. Definition of Types of Cost

TYPE A. Constant annual costs which do not vary according to the rate of offtake per day, distance from Nairobi, total number of days in the field or number of days per operation.

Head Office Staff

Manager	Shs.60,000/- p.a.
Accounts Assistant	Shs.19,200/- p.a.
Typist	Shs.12,000/- p.a.
Stores Foreman	Shs.12,000/- p.a.
Messenger	Shs. 3,600/- p.a.
Watchman	Shs. 3,600/- p.a.

Head Office Expenses

Office rent	Shs.18,000/- p.a.
Electricity	Shs. 480/- p.a.
Water	Shs. 180/- p.a.
Stationery	Shs. 600/- p.a.
Telephone	Shs. 1,200/- p.a.
Depreciation and maintenance of office equipment	Shs. 4,000/- p.a. (Shs.40,000/- x 10%)

Total Type A Costs = Shs.134,860/- p.a.

TYPE B. Annual costs which vary according to the rate of offtake per day but are not influenced by the distance from Nairobi, the total number of days in the field or the number of days per operation.

Salaries

Field Staff

Assistant Manager	Shs.24,000/- p.a.
Abattoir Foreman	Shs.12,000/- p.a.
Shooter	Shs.12,000/- p.a.
Collector	Shs. 5,400/- p.a.
Skinner	Shs. 5,400/- p.a.
Flesher	Shs. 5,400/- p.a.
Eviscerator	Shs. 5,400/- p.a.
Splitter	Shs. 5,400/- p.a.

Drivers

Abattoir	Shs. 5,400/- p.a.
Insulated van	Shs. 9,600/- p.a.
Pick-up	Shs. 5,400/- p.a.
Mini-moke	Shs. 5,400/- p.a.
Water tanker	Shs. 6,600/- p.a.
Lorry	Shs. 6,600/- p.a.

Vehicle Insurance

Minimum Third Party Insurance on all vehicles at Shs.400/- per vehicle p.a.

Interest

The capital costs of the vehicles, abattoir unit, compressor and generator are given below at 125% of the original price paid by the Wildlife Management Project to allow for recent price rises.

	Capital Cost Shs.	Interest (10%) Shs.
Abattoir - Unit	65,000	6,500
- Extension	40,000	4,000
- Prime Mover *	65,000	6,000
Water tanker	62,500	6,250
Mini-moke	22,500	2,250
Pick-up	50,000	5,000
Lorry	123,125	12,312.5
Generator (inc. trailer)	32,500	3,250
Compressor (inc. trailer)	32,500	3,250
Insulated van - unit	66,250	6,625
- prime mover *	50,000	5,000
Camping equipment (staffed for 20-40 and 30-120 animals/day)	15,000	1,500
Camping equipment - additional (staffed for 40-80 and 120-150 animals/day)	11,250	1,125
Abattoir equipment (for each production line)	16,875	1,687.5
Miscellaneous equipment (for up to 80 animals/day)	10,000	1,000
Office equipment	40,000	4,000

TYPE C. Costs which vary according to the rate of offtake per day and total number of days in the field but are not influenced by distance from Nairobi nor the number of days per operation.

* The additional prime mover purchased to haul the extra insulated van units required as the offtake rate per day rises is less expensive than the prime mover purchased to haul the abattoir unit because it does not need to be so powerful.

Depreciation of Vehicles and Equipment

Annual depreciation rate is the cost that would be incurred if the firm was operating for the maximum number of days in the field (250) and will vary according to the offtake rate per day. The firm will not necessarily spend the maximum number of days in the field since this will be determined by the offtake rate per day and the annual offtake rate. Hence, depreciation is calculated on a daily basis (i.e. annual depreciation (Shs.) ÷ 250).

	Annual Depreciation Rate	Depreciation Per Day Shs.
Abattoir - unit	12½%	32.5
- extension	20 %	32
- prime mover	20 %	52
Water tanker	15 %	37.5
Mini-moke	30 %	27
Pick-up	30 %	60
Lorry	15 %	73/87
Generator (inc. trailer)	25 %	32/50
Compressor (inc. trailer)	25 %	32/50
Insulated van - unit	20 %	58
- prime mover	20 %	40
Abattoir equipment (for each production line)	30 %	20/25
Camping equipment (staffed for 20-40 and 80-120 animals/day)	30 %	18
Camping equipment - additional (staffed for 40-80 and 120-160 animals/day)	30 %	13/50
Miscellaneous equipment (for each 80 animals/day)	30 %	12

Maintenance

(Including petrol costs) of pick-up being used for animal collection - Shs.20/- per vehicle per day.

Inspectors

Field allowance of Shs.20/- per day.

Maintenance of Equipment

Abattoir - each production line including equipment	Shs.30/- per day
Compressor (inc. trailer)	Shs.20/- per day
Generator (inc. trailer)	Shs.20/- per day
Camping equipment (staffed for 20-40 and 80-120 animals/day)	Shs.10/- per day
Camping equipment - additional (staffed for 40-80 and 120-160 animals/day)	Shs.7/50 per day

TYPE D. Costs which vary according to the rate of offtake per day and distance from Nairobi.

Insulated van maintenance costs including petrol Shs.1/65 per km.

TYPE E. Costs which vary on a daily basis, according to the length of each operation, the distance from Nairobi and the rate of offtake per day.

Setting up and Dismantling Costs

All staff is on a salaried basis and no additional labour is required therefore the only costs incurred are those of moving vehicles and equipment.

Abattoir	Shs.1/65 per km.
Insulated van	Shs.1/65 per km.
Water tanker	Shs.1/65 per km.
Mini-moke	Shs.1/- per km.
Pick-up	Shs.1/40 per km.
Lorry	Shs.1/60 per km.

TYPE F. Costs which vary proportionately to the annual offtake rate.

Ammunition - 1½ rounds/animal at Shs.2/60 each
+ 1 round/4 animals at 60 cents each
(for animals not properly shot)
= Shs.4.05 per animal.

Salt - 3 kg/animal at Shs.7/- per 20 kg = Shs.3.55

Soap, Bactergent etc. - 20 cents per animal

Mini-sacks - 1 km per animal at Shs.1/- per km = Shs.1/-

Pick-up - 3 animals per round trip of 6 km at Shs.1/40 per km = Shs 2/80 per animal

Water Requirements

Approximately 0.033 m sh. where m is the distance from Nairobi. A detailed analysis shows this figure to be reasonably accurate for any given level of offtake but crudely taking the capacity of the water tanker at 2,300 gallons and approximately 23 gallons per animal including an element for human needs and the cost of the water tanker at Shs.1/65 per km then 0.033 m sh. is the approximate cost/animal.

Due to the potential discrepancies of calculating costs at this micro level, variable costs per animal have been rounded to Shs.20/-.

Total Type F - Shs.20/- per animal

b. BREAKDOWN OF COSTS WHICH VARY ACCORDING TO OFFTAKE/DAY

TYPE B COSTS

Number of animal units/day	Total Type B Costs p.a. (excluding interest) Shs.	Interest Costs p.a. Shs.
20	147,200	70,125
26+	163,400	
40+	241,000	84,187.5
50+	251,000	95,812.5
53+	256,400	
60+	267,200	
66+	272,600	
80+	397,800	138,750
93+	459,000	
100+	469,000	148,625
106+	492,200	154,875
120+	569,800	168,937.5
133+	575,200	
140+	586,000	
146+	592,400	
150+	601,400	175,562.5

BREAKDOWN OF TYPE C COSTS - PER DAY

No. animals/ day units	Depreciation vehicles and equipment (Sh)	Maintenance of equipment (Sh)	Maintenance (& petrol) of pick-ups not used for collection (Sh)	Inspectors	TOTAL
20+	571.12	80	40	40	731.12
40+	723.87	110	40	60	933.87
50+	816.87	110	40	60	1006.87
60+	816.87	110	40	80	1026.87
80+	1088.12	147.5	60	100	1395.62
100+	1173.62	167.5	60	120	1521.12
106+	1211.12	167.5	60	120	1558.62
120+	1363.87	197.5	60	140	1761.37
140+	1363.87	197.5	60	160	1781.37
150+	1416.87	197.5	60	160	1815.37

TYPE D COSTS

Maintenance (including petrol) costs of insulated vans at Shs.1/65 per km. Let m be the distance (km) from Nairobi.

	Sh/day
20+ animal units/day	
1 van/1 trip every 2 days	1/65 m
25+ animal units/day	
1 van/1 trip every day	3/30 m
50+ animal units/day	
1 van/1 trip every day	
1 van/1 trip every 2 days	4/95 m
75+ animal units/day	
2 vans/1 trip every day	6/60 m
100+ animal units/day	
2 vans/1 trip every day	
1 van/1 trip every other day	8/25 m
125+ animal units/day	
3 vans/1 trip every day	9/90 m
150+ animal units/day	
3 vans/1 trip every day	
1 van/1 trip every 2 days	11/55 m

TYPE B COSTS. Setting up and dismantling costs per operation.

The prime mover transports the abattoir unit to cropping site and returns to Nairobi to collect insulated van unit.

At end of operation prime mover leaves insulated van unit in Nairobi after last lead and returns to site to collect abattoir unit.

Let m be the distance (km) from Nairobi.

	Setting up Costs (Sh)	Dismantling Costs (Sh)	TOTAL (Sh)
20+ animal/units/day	11/80 m	8/50 m	20/30 m
40+ animal units/day	14/20 m	10/90 m	25/10 m
50+ animal units/day	15/85 m	10/90 m	26/75 m
80+ animal units/day	20/30 m	15/35 m	35/65 m
100+ animal units/day	23/60 m	15/35 m	38/95 m
106+ animal units/day	25/25 m	17/00 m	42/25 m
120+ animal units/day	27/65 m	19/40 m	47/05 m
150+ animal units/day	29/30 m	19/40 m	48/70 m

V SUMMARY OF CROPPING COSTS AND REVENUES

This section is mainly devoted to tables which set out the potential cropping costs and revenues for a range of situations. On the whole these tables speak for themselves and the following discussion serves only to make them a little more complete.

Tables B and C set out in detail the way in which cropping costs change as the daily offtake rate changes. In order to calculate these costs certain assumptions about offtake have been made. Firstly, calculations are based on an average of five hundred animals being taken in each operation, although, obviously this figure will vary according to the local density of animals. Secondly, the

maximum number of days operating in the field is two hundred and fifty. While feasible on paper, in practice this would require a high level of efficiency. Thirdly, Table B sets out calculations for up to 20,000 animals per annum. This represents 10% of the potentially croppable wildlife population but a cropping operation would not reach this figure because some areas are dedicated to the conservation of wildlife (Nairobi National Park, Amboseli Game Reserve and Kitengela) and other areas cannot be cropped because of unsuitable terrain and inadequate communication systems. Therefore, although Table B shows how cropping costs change over a wide range of annual offtake rates, in practice the real issue is at the lower end of the scale. To this end Table C sets out in even more detail the relationship between cropping costs and the daily and annual offtake rates, showing that cropping costs are in the region of Shs.150/- ± 20% per animal.

Table D gives data on the return per animal, by species, for a range of meat prices. At present Shs.3/50 per kg. is a realistic price for meat which is sold as soon as it reaches Nairobi. However, at this price it would only be profitable to crop zebra, eland, kongoni and wildebeest. Market development could increase this price but if this means storage, packaging and distribution costs then the price rise would have to be greater than the costs incurred if net revenue per cropped animal is to be increased.

TABLE A. Relationship between offtake/day, number of days/operation and number of days in field per annum.

CONSTRAINTS
1. Max. No. animal units p.a. = 20,000 (arbitrary maximum)
2. Average No. animal units per operation = 500
3. Max. No. days cropping p.a. = 250
4. Max. No. days per operation = 25
5. Max. No. days in the field including setting up and dismantling is 290

(1)	(2)	(3)	(4)	(5)	(6)
	Max $\frac{500}{(1)}$	$250 - \frac{(250 \times (2) - 20{,}000)}{(2)}$ if ( ) 0	(2) x (1)	(3) ÷ (1)	(3) ÷ (5)
No. days/oper Operation	Daily Offtake	Total No. of days cropping in field	Annual Offtake	No. of Operations	Total No. days + in field
25	20	250	5,000	10	260
20	25	250	6,250	13	263
15	33	250	8,250	17	267
10	50	250	12,500	25	275
6½	77	250	19,250	39	289
6	83	241	20,000	40	281
5½	91	220	20,000	40	260
5	100	200	20,000	40	240
4½	111	180	20,000	40	220
4	125	160	20,000	40	200
3½	143	140	20,000	40	180
3	160 (167)	125	20,000	42 *	167

* Max. daily offtake at 3 day operation is $\frac{500}{3}$ = 167 animals but max. capacity is 160

\+ ½ day setting up + ½ day dismantling.

TABLE B. Cropping Costs

(1) No. animal units per day	(2) Annual Offtake (a.u)	(3) Type of cost (sh per animal A	(4) B	(5) C
20	5,000	26.97	29.44	36.56
25	6,250	21.58	23.55	29.24
25+	6,500	20.75	22.65	28.12
26+	6,750	19.98	24.21	27.08
40	10,000	13.49	16.34	18.28
40+	10,250	13.16	23.52	22.78
50	12,500	10.79	19.28	18.68
50+	12,750	10.58	20.39	19.74
53	13,250	10.18	19.63	19.00
53+	13,500	9.99	18.99	18.65
60	15,000	8.99	17.09	16.78
60+	15,250	8.84	17.52	16.83
66	16,500	8.17	16.20	15.56
66+	16,750	8.05	16.27	15.33
75	18,750	7.19	14.54	13.69
75+	19,000	7.10	14.34	13.51
80	20,000	6.74	13.63	12.84
80+	20,000	6.74	19.89	17.23
93	20,000	6.74	19.89	15.01
93+	20,000	6.74	22.35	14.85
100	20,000	6.74	22.35	13.96
100+	20,000	6.74	23.45	15.06
106	20,000	6.74	23.45	14.35
106+	20,000	6.74	24.61	14.57
120	20,000	6.74	24.61	12.99
120+	20,000	6.74	28.49	14.56
125	20,000	6.74	28.49	14.09
125+	20,000	6.74	28.49	13.98
133	20,000	6.74	28.49	13.24
133+	20,000	6.74	28.76	13.24
140	20,000	6.74	28.76	12.58
140+	20,000	6.74	29.30	12.63

(6)	(7)	(8)	(9)	(10)
unit excluding interest)				
D	E	F	Total Costs per animal (Sh) unit	Total Costs per day (sh)
8.25	4.06	20	125.28	2,506
6.60	4.06	20	105.03	2,626
12.7	4.06	20	108.28	2,815
12.2	4.06	20	107.53	2,903
8.25	4.06	20	80.42	3,217
8.1	5.02	20	92.57	3,796
6.60	5.02	20	80.36	4,018
9.70	5.25	20	85.76	4,374
9.34	5.35	20	83.50	4,425
9.17	5.35	20	82.15	4,436
8.25	5.35	20	76.46	4,588
8.15	5.35	20	76.69	4,678
7.50	5.35	20	72.78	4,803
7.40	5.35	20	72.40	4,851
6.60	5.35	20	67.37	5,053
8.68	5.35	20	68.98	5,242
8.25	5.35	20	66.81	5,345
8.15	7.13	20	79.14	6,410
7.10	7.13	20	75.87	7,056
7.00	7.13	20	78.27	7,339
6.60	7.13	20	76.78	7,678
8.17	7.79	20	81.21	8,202
7.78	7.79	20	80.11	8,492
7.71	8.45	20	82.08	8,783
6.87	8.45	20	79.66	9,559
6.82	9.41	20	86.02	10,408
6.60	9.41	20	85.33	10,662
7.86	9.41	20	86.48	10,896
7.44	9.41	20	85.32	11,348
7.39	9.41	20	85.44	11,449
7.07	9.41	20	84.56	11,838
7.02	9.41	20	85.10	11,999

TABLE B (Continued)

(1) No. animal units per day	(2) Annual Offtake (a.u)	(3) Type of cost (sh per animal unit excluding interest) A	(4) B	(5) C	(6) D	(7) E	(8) F	(9) Total Costs per * animal (sh) unit	(10) Total Costs * per day (sh)
146	20,000	6.74	29.30	12.20	6.78	9.41	20	84.43	12,327
146+	20,000	6.74	29.57	12.12	6.73	9.41	20	84.57	12,432
150	20,000	6.74	29.57	11.87	6.60	9.41	20	84.19	12,629
150+	20,000	6.74	30.07	12.02	7.65	9.74	20	86.22	13,019
160	20,000	6.74	30.07	11.35	7.22	9.74	20	85.12	13,619

Notes:

(2) Annual offtake = No. animals/day x 250 or 20,000 whichever is less.

(3) Type A costs/animal = 134,860 ÷ annual offtake.

(4) Type B costs/animal = Type B costs p.a. ÷ annual offtake. Excludes interest costs.

(5) Type C costs/animal = Type C costs/day ÷ offtake rate/day.

(6) Type D costs/animal = Type D costs/day ÷ offtake rate/day.

m = 100 km

(7) Type E costs/animal = Type E costs/operation ÷ 500

(9) Total costs/animal = Type A + B + C + D + E + F costs/animal.

(10) Total costs per day = Offtake rate per day x total costs per animal.

* Discrepancies due to rounding.

TABLE C. Cropping Costs

Offtake/ day (a.u)	Annual Offtake (a.u)	Type of Cost (sh. per animal unit excluding interest) A	B	C	D	E	F	Total Cost/ animal unit (sh)	Total Cost/day (sh)
20	2,500	53.94	58.88	36.56	8.25	4.06	20	181.69	3,634
	3,000	44.95	49.07	36.56	8.25	4.06	20	162.89	3,258
	3,500	38.53	42.06	36.56	8.25	4.06	20	149.45	2,989
	4,000	33.72	36.80	36.56	8.25	4.06	20	139.38	2,788
	4,500	29.97	32.71	36.56	8.25	4.06	20	131.55	2,631
	5,000	26.97	29.44	36.56	8.25	4.06	20	125.28	2,506
25	2,500	53.94	58.88	29.24	6.6	4.06	20	172.73	4,318
	3,000	44.95	49.07	29.24	6.6	4.06	20	153.92	3,848
	3,500	38.53	42.06	29.24	6.6	4.06	20	140.49	3,512
	4,000	33.71	36.8	29.24	6.6	4.06	20	130.42	3,261
	4,500	29.97	32.71	29.24	6.6	4.06	20	122.58	3,065
	5,000	26.97	29.44	29.24	6.6	4.06	20	116.32	2,908
26	2,500	53.94	58.88	28.12	12.69	4.06	20	177.70	4,620
	3,000	44.95	49.07	28.12	12.69	4.06	20	158.89	4,131
	3,500	38.53	42.06	28.12	12.69	4.06	20	145.46	3,782
	4,000	33.72	36.80	28.12	12.69	4.06	20	135.39	3,520
	4,500	29.97	32.71	28.12	12.69	4.06	20	127.55	3,316
	5,000	26.97	29.44	28.12	12.69	4.06	20	121.28	3,153
27	2,500	53.94	65.36	27.08	12.22	4.06	20	182.66	4,932
	3,000	44.95	54.47	27.08	12.22	4.06	20	162.78	4,935
	3,500	38.53	46.69	27.08	12.22	4.06	20	148.58	4,012
	4,000	33.72	40.85	27.08	12.22	4.06	20	137.93	3,724
	4,500	29.97	36.31	27.08	12.22	4.06	20	129.64	3,500
	5,000	26.97	32.68	27.08	12.22	4.06	20	123.01	3,321
40	2,500	53.94	65.36	18.28	8.25	4.06	20	169.89	6,796
	3,000	44.95	54.47	18.28	8.25	4.06	20	150.01	6,000
	3,500	38.53	46.69	18.28	8.25	4.06	20	135.81	5,432
	4,000	33.72	40.85	18.28	8.25	4.06	20	125.15	5,006
	4,500	29.97	36.31	18.28	8.25	4.06	20	116.87	4,675
	5,000	26.97	32.68	18.28	8.25	4.06	20	110.24	4,410

TABLE C. (Continued)

Offtake/ day (a.u)	Annual Offtake (a.u)	Type of Cost (sh. per animal A	B	C
41	2,500	53.94	96.40	22.78
	3,000	44.95	80.33	22.78
	3,500	38.53	68.86	22.78
	4,000	33.72	60.25	22.78
	4,500	29.97	53.56	22.78
	5,000	26.97	48.20	22.78
50	2,500	53.94	96.40	18.68
	3,000	44.95	80.33	18.68
	3,500	38.53	68.86	18.68
	4,000	33.72	60.25	18.68
	4,500	30.00	53.56	18.68
	5,000	26.97	48.20	18.68
80	2,500	53.94	109.04	12.84
	3,000	44.95	90.87	12.84
	3,500	38.53	77.89	12.84
	4,000	33.72	68.15	12.84
	4,500	29.97	60.58	12.84
	5,000	26.97	54.52	12.84

unit excluding interest) D	E	F	Total Cost/ animal unit (sh)	Total Cost/day (sh)
8.05	5.02	20	206.19	8,454
8.05	5.02	20	181.13	7,426
8.05	5.02	20	163.23	6,692
8.05	5.02	20	149.81	6.142
8.05	5.02	20	139.37	5,714
8.05	5.02	20	131.02	5,372
6.6	5.02	20	200.64	10,032
6.6	5.02	20	175.58	8,779
6.6	5.02	20	157.69	7,884
6.6	5.02	20	144.26	7,213
6.6	5.02	20	133.82	6,691
6.6	5.02	20	125.47	6,273
8.25	5.35	20	209.42	16,754
8.25	5.35	20	182.26	14,580
8.25	5.35	20	162.85	13,028
8.25	5.35	20	148.30	11,864
8.25	5.35	20	136.98	10.959
8.25	5.35	20	127.93	10,234

TABLE D. PRODUCTION COSTS AND REVENUE PER ANIMAL BY SPECIES

	Kongoni	Eland	Impala
Average carcass weight (kg)	50	200	20
1 animal as fraction of 1/ an animal unit	1	2	2/3
Cropping Costs (sh) 3/ 1 a.u. = 150/-	150/-	300/-	100/-
Value of Skins	20	25	25
Sale price of meat 3/50 per kg.			
Value of meat (sh)	175	700	70
Revenue from meat & skins (sh)	195	725	95
Net revenue (10% wastage) (sh)	45 (25.5)	425 (352.5)	-5 (-14.5)
Sale price of meat 4/50 per kg.			
Value of meat (sh)	225	900	90
Revenue from meat & skins (sh)	245	925	115
Net revenue (10% wastage)(sh)	95 (70.5)	625 (532.5)	15 (3.5)
Sale price of meat 5/- per kg.			
Value of meat (sh)	250	1000	100
Revenue from meat & skins (sh)	270	1025	125
Net revenue (10% wastage) (sh)	120 (93)	725 (622.5)	25 (12.5)
Sale price of meat 5/50 per kg.			
Value of meat (sh)	275	1100	110
Revenue from meat & skins (sh)	295	1125	135
Net revenue (10% wastage) (sh)	145 (114.5)	825 (712.5)	35 (21.5)

Grant's Gazelle	Thomson's Gazelle	Zebra	Wildebeest
20	9	100	75
2/3	½	1	1
100/-	75/-	150/-	150/-
35	25	300	30 2/
70	31.5	350	262.5
105	56.5	650	292.5
5 (-5.5)	-18.5 (-24.15)	500 (435)	142.5 (116.25)
90	40.5	450	337.5
125	65.5	750	367.5
25 (12.5)	-9.5 (-15.5)	600 (525)	217.5 (180.75)
100	45	500	375
135	70	800	405
35 (21.5)	-5 (-12)	650 (570)	255 (214.5)
110	49.5	550	412.5
145	74.5	850	442.5
45 (30.5)	0.5 (-6.95)	700 (615)	292.5 (250.25)

TABLE D. (Continued)

	Kongoni	Eland	Impala	Grant's Gazelle	Thomson's Gazelle	Zebra	Wildebeest
Sale price of meat 6/- per kg.							
Value of meat (sh)	300	1200	120	120	54	600	450
Revenue from meat & skins (sh)	320	1225	145	155	79	900	480
Net revenue (10% wastage) (sh)	170 (138)	925 (802.5)	45 (30.5)	55 (39.5)	4 (-3.9)	750 (660)	330 (298)

1/ Based on average weights and adjusted according to interpretation.

2/ Inelastic demand for wildebeest skins appears to exist therefore a cropping operation resulting in the production of substantial increase in supply is likely to force prices down to the equivalent of cowhide prices (20/- per skin).

3/ Cropping costs of 150/- per animal unit is based on findings in Table C and do not include storage, packing or distribution costs in Nairobi.

CHAPTER IV

SOME LAND USE OPTIMISATION PROBLEMS

INTRODUCTION

This thesis is concerned with a particular area of land, namely Kajiado District. Previous chapters have described the area and studied the two main forms of land use which might be practised there. The next obvious step is to discuss the way in which these forms of land use may be combined to provide an optimum pattern of land use not only for that particular area but also within the pattern of land use in the whole of Kenya. The question of optimising land use is particularly pertinent because the three basic resources of land labour and capital are employed to a varying extent, in any human activity. However, whereas the labour supply grows as the population increases and the capital supply expands as a result of economic growth the total supply of land is fixed. It is essential, therefore, to undertake land planning in medium and low potential areas as well as high potential areas.

This chapter is divided into two sections.

Section I covers some general aspects of land use planning and is in three parts:-

Part A discusses the objectives of land planning.
Part B covers the criteria used in land planning.
Part C considers some of the problems of adopting a theoretical approach.

Section II looks at land use planning in Kajiado District.

Part A applies land planning criteria to this area.
Part B discusses some of the problems of determining the optimum land use patterns.
Part C outlines a case study which evaluates two alternative forms of land use.

SECTION I

SOME GENERAL ASPECTS OF LAND USE PLANNING

A Objectives of land use planning

The need for land planning is brought about by the increasing competition for land which has resulted from a growing population needing space to live and grow food and the pursuit of economic growth causing an increasing amount of land to be utilised for non-agricultural purposes. In other words the general objective of land planning is the optimisation of social welfare over time. More specifically, the objectives of land planning are threefold.

Resource Preservation

Natural resources, whether renewable or not, are limited and, therefore, in the long term economic interest their preservation is of considerable interest. In the Kenyan situation the preservation of wildlife is of particular importance since the tourist industry, one of the main industries in Kenya, is based on this natural resource. Forest and vegetation preservation is important not only for soil and water conservation but also in an attempt to maintain and improve the habitat status, and hence, the productive potential of the land.

Efficient Resource Utilisation

Since the supply of resources is limited it is essential that they are efficiently utilised both in a technical and economic sense. Inefficient use of resources implies a cost to the individual and to the

society as a whole. Therefore, land planning should take account of the existing and potential utilisation and distribution of resources.

The Development of Optimal Land Use Patterns

Ideally, the pattern of land use should be such that the activity occurring on any given area of land is making the maximum contribution to total national welfare.

B Land Planning Criteria

There are four major criteria which influence land planning policies.

Social Criteria

Patterns of land use should take account of the existing and future social structure of the local population. In Kenya many different tribes and races exist, each with its own specific social organisation which in many cases influence the way in which the land is utilised. For example, the Maasai are nomadic pastoralists whereas the Kipsigis are agriculturalists. Also under this heading account should be taken of those costs and benefits to the society which cannot be expressed in monetary terms. For example, the Maasai appear to have a strong desire to maintain their traditional way of life for social, as well as economic reasons.

Ecological Criteria

The physical aspects of the land such as microclimate, topology, soil, water distribution and vegetation dictate the potential uses of a given area for a given capital input.

Economic Criteria

The pattern of land use should be such that the contribution of each area of land to the national economy is maximised. If the form of land use is determined by an individual then his choice will depend on the private costs and returns facing him, his personal desires and prejudices and legal constraints. If private costs and returns are not in line with public costs and returns and if the legal constraints are not appropriate, then the landowner is unlikely to fulfil the criteria of maximising the contribution to the national economy.

Political Criteria

Political criteria which do not necessarily have a bearing on the criteria discussed above may also influence land planning policies. For example, a developing country may expand a particular industry not because it is the most vital sector in economic growth but because another country, for reasons of its own, is offering aid to develop that particular industry. For example, under the World Bank Livestock Development Plan, Sweden offers aid in the field in which it is highly experienced, namely, water development.

C Some Problems of Utilising Theoretical Land Planning Techniques

Some General Problems

A wide range of problems are likely to arise in the application of a general theoretical land planning technique, such as costs-benefit analysis or the marginal approach, to a particular situation. Firstly, each situation has its own peculiarities and within

the framework of a generalised technique it may not be possible to take account of these factors. Secondly, if a technique is comprehensive for a range of situations then by virtue of its comprehensive nature it is likely to be complex and hence difficult to manipulate. In practice, however, the real situation may be rendered quite simple by the constraints which are operating. Thirdly, a theoretical approach assumes full knowledge of the situation whereas in practice, particularly in a developing country, knowledge may be severely limited. Fourthly, full access to the necessary data is assumed. However, in many cases the appropriate data may not exist or be in a manageable form. Obtaining this data may well be a costly process both in terms of time and money. These problems are exemplified if we discuss the two known techniques named above: cost benefit analysis and the marginal approach.

Cost Benefit Analysis

Cost benefit analysis is a general technique which can be used for appraising a wide range of projects. Briefly, the approach adopted is to list and evaluate the social and financial costs and benefits of a given project over time, discount them back to the present, and hence determine the value of the present net cost or benefit. It is therefore, particularly applicable in a land planning exercise since it can be used to evaluate the net costs or benefits of utilising a given area of land in a particular way, taking social costs and benefits into account as well as economic ones. Where there is a range of potential land uses,

cost benefit analysis can be used to determine the optimum form of land use since the project which yields the greatest net benefit is the form of land use which is making the greatest contribution to community welfare. As far as the Government is concerned, it is a very appropriate tool because it takes account of the social benefits and costs which would not be taken into account by the private individual who is influenced by market prices, but which do add to, or detract from, total social welfare.

While in theory this appears to be a first class approach several problems are encountered when actually utilising this analysis which considerably limit its value as a planning tool. Firstly, the relevant factors which need to be included in the analysis must be determined. This is a somewhat subjective exercise and is likely to vary according to the economist carrying out the analysis. Secondly, these factors are evaluated. Depending on the method of pricing, e.g. opportunity cost or accounting prices, so the resulting answer will be influenced. Thirdly, in practice, putting a monetary value on things which are not valued in the market place must be a very arbitary process. Different economists will use different criteria, and hence, put in different values for the same factor. For example, what is the social benefit of piping water to a village so that the women do not have to walk five miles to collect water? This could be evaluated in many ways such as the value of goods the women could produce in the time saved or the value of the additional time they can spend caring for their children. Fourthly, this analysis attempts to take future benefits and costs

into account as well as present ones. However, there is uncertainty over future changes in aspects such as demand, technology and politics. Again, the values put in will depend on the opinions of the individual economist. The four problems outlined above combine to make cost benefit analysis very vulnerable to the prejudices of the economist involved with the result that different economists are likely to get very different results for the same project. Fifthly, cost benefit analysis gives a very precise answer giving it an air of accuracy which it does not deserve, because, by necessity, it will have to be based on assumptions of varying degrees of accuracy. Sixthly, because this analysis is so subjective to the economist actually making the evaluations, comparison of projects which have been evaluated by this method may be misleading. Hence, while in theory cost benefit analysis is a commendable technique, in practice it must be used with great care for decision-making purposes.

The Marginal Approach

As its name suggests, the marginal approach is a technique which examines costs and revenues at the margin of an activity. It can be used to identify the optimum level (i.e. the point where profit is maximised) of production. In other words the level of activity should be increased to the point where the marginal cost of producing another unit is equal to the marginal revenue gained from producing that unit. At a lower level of production profit is being foregone since marginal revenue is greater than marginal costs for the last unit. If this level of production is exceeded

the reverse becomes true and again profit is not being maximised. This approach is also useful in determining the optimum level of production for different activities which are competing for the same resource. The optimum situation is realised where the marginal net revenue from the last unit of the scarce resource being used in each activity is equal for all the activities. If the marginal net revenue for any one activity is greater than the marginal net revenue for the other activities then the overall profit can be increased by expanding production in the former activity at the expense of some production in the other activities. This approach was put forward by P.H. Pearse at the 1967 East African Agriculture and Forestry Organisation Symposium on Wildlife Management and Land Use when he applied it to the problem of game and cattle competing for the same area of land, and it is relevant to discuss this approach more fully here.

The problem is set out graphically in Figure IV[I] (at the end of this chapter). The production-possibility curve (AB) indicates the various combinations of game and cattle that can use a given area of rangeland to its full capacity but without being overstocked. MN is the price line and indicates the ratio of the value of production (sale of animals + milk production) from a herd of cattle on a per animal basis and the value of production (sale of animals for hunting, cropping and capture - exclude tourism because it poses problems discussed later) from game animals on a per animal basis. Profit is maximised at E where MN is a tangent to AB i.e. Y cattle and X game. If one moves from this situation by replacing game by cattle then the

revenue from the extra cattle is less than the revenue from game foregone, thus reducing profits. Likewise if cattle are replaced by game, profits are not being maximised.

Several problems arise when actually applying this technique in practice. Firstly, the area considered must be sufficiently large to encompass an ecosystem since the analysis is somewhat meaningless if the game animals only spend half the year in the area under study but the cattle remain there for the whole year. The marginal approach cannot satisfactorily cope with this type of problem and yet in most cases ranches are not sufficiently large to encompass migration patterns. Secondly, game is not homogenous. Part of the argument that the range per given land unit supports a higher biomass (i.e. the total animal weight) of game than cattle rests on the fact that the presence of many species ensures total habitat utilisation. This subject has been researched by numerous people such as R.F. Dasmann, D. Hopcraft and F.F. Darling. Each species overlaps with cattle in a different way so that it would seem impossible to reduce all species of game to a common unit in terms of its competition with cattle. In addition, some species actually complement cattle production. For example, giraffe assist in bush control. Thirdly, there is a serious lack of the data required to actually draw up the production-possibility curve. Fourthly, although this analysis attempts to answer the question "how many"? it does not solve any of the locational problems. Because of problems such as disease transmission and game damage to fences and constructions, a degree of separation is desirable. Also, in terms of habitat type and water availability, some areas are more

suitable for cattle and others for game. Fifthly, because of its marginal nature this technique cannot deal with the tourist aspect. One animal more or less is not going to marginally change revenue from tourism but revenue from tourism cannot be written in as a constant because a significant drop in the numbers of game will result in a reduction, though not necessarily proportional, in tourist revenue. This problem has been examined fully in Chapter III. Thus, as with cost benefit analysis, while the principles behind this type of analysis are sound, the problems of utilising it are sufficiently great to limit its value as a land planning tool.

SECTION II

SOME ASPECTS OF LAND USE PLANNING IN KAJIADO DISTRICT

A The Application of Land Planning Criteria to Kajiado District

The land planning criteria outlined above can be applied to Kajiado District in the following way.

Social Criteria

Currently the Maasai are operating a subsistance economy based on their livestock as described in Chapter I. In spite of the development that has occurred in Kenya they have resisted the changes and many are still living a traditional way of life giving the impression that they do not want to change. This impression is reinforced by the slow response to loans offered under the World Bank Livestock Development Plan.

Political Criteria

The Government of Kenya wants to induce economic development. One method is to accept overseas aid to develop various industries. As has been described in

Chapter I, the United States of America, Great Britain and Sweden have offered considerable financial aid to Kenya through the World Bank Livestock Development Plan to develop Kenya's beef industry. Kajiado District is one of the main livestock rearing areas, and therefore, although the Maasai appear unwilling to change from their traditional way of life the Government is attempting to settle them on ranches and develop commercial cattle production there to its full potential.

Economic Criteria

The tourist industry is one of the main growth sectors and a major earner of foreign exchange. Since a significant part of the industry depends on the wildlife attraction the Kenya Government is committed to the preservation of wildlife. Kajiado District is already committed as a game area, firstly because two of Kenya's most economically important game parks, Nairobi National Park and the Amboseli Reserve, are situated there, and secondly, because it is a major hunting area. Therefore, applying economic criteria at a national level it is in the national interest to expand the wildlife utilisation activities already established in this area, to their full potential. The questions which remain to be answered are "what is the optimum size of each activity?" and "where should game be preserved in addition to the existing national parks and their wet season dispersal areas?" The answers to these questions will depend on the contribution of alternative forms of land use to the national economy. As described above, the contribution of the main alternative form of land use, namely cattle rearing, is considerable particularly once it has been developed under the World Bank Livestock Development Plan.

Ecological Criteria

The ecological criteria dictate the potential forms of land use. For the majority of Kajiado District, that is the semi-arid plains and bush area, the only feasible forms of land use are by domestic stock or wildlife. Livestock can be utilised at two levels: commercial for the sale of young animals and slaughter stock and at subsistence level for milk and meat. While commercial cattle production is being developed in this area it seems probable that the Maasai livestock will also continue providing subsistance requirements for some considerable time. At the moment the forms of wildlife utilisation which are being practised are viewing by tourists, hunting and capture. It is possible to utilise game populations in all three ways concurrently, though these activities would have to be carried out in separate areas.

Having applied some land planning criteria to Kajiado District it can be seen that once the major constraints have been taken into account the problem of determining an optimum land use pattern is simplified though by no means simple. In summary, ecologically the majority of this area can only be used by cattle or game. The Government of Kenya, aiming to induce economic development is prepared to accept aid which is given for specific purposes. A considerable amount of aid has been offered through the World Bank to develop the livestock sector and since Kajiado District has considerable potential for commercial cattle production, it is being developed under the scheme. Also, in the pursuit of economic development the Kenya Government is developing the tourist industry,

a considerable part of which is founded on the wild-life attraction. Hence, the Government is committed to the conservation of game.

As two national parks have already been set up there it makes economic sense to develop the tourist industry in this area to its full potential. This area is also important for hunting as was discussed in Chapter III. The question of the balance between these potential forms of land use should be decided by economic criteria on the basis of the contribution of each activity to the national economy.

B Some Land Use Optimisation Problems in Kajiado District

While optimum land use criteria and theoretical techniques can be applied to this area, there are three major sets of problems which have to be overcome before a realistic land planning programme can be determined and introduced in this area.

a. Some Land Planning Problems

Lack of Data

The real problem in this sphere is the lack of integrated and coordinated data. On the whole, much of the research done in this area has been carried out by individuals working in localised areas on specific aspects, and often for a limited period of time. The Agricultural Finance Corporation, of course, has considerable knowledge of the livestock sector in the development areas and the Wildlife Management Project is working on some aspects of the wildlife but there has been no attempt to combine this knowledge and establish the relationship between the two sectors. The

result is that assumptions made on the basis of such "spotty" information and applied to the whole of Kajiado District are liable to give misleading results because of the climatic, geological and ecological variations over time and space in this area.

Evaluation Problems

Since the Maasai economy is at subsistence level the value of the main products which they consume, milk, meat, hides and blood, are not by definition valued in the market place. Therefore, it is necessary to decide to what extent the value of the subsistence economy should be included in an analysis and at what prices.

For example, labour is used to herd and milk the cows, but should it be evaluated on the basis of opportunity cost or the cost of hired labour? Similarly, should subsistence milk be evaluated at production costs, wholesale price or retail price. These difficulties highlight the problems of using a technique such as cost benefit analysis. The following analysis of potential revenues from cattle ranching or game cropping discussed these problems more fully, showing the different results given depending on the evaluation criteria employed.

b. Wildlife Utilisation Problems

The nature of wildlife is such that in order to maintain a sufficiently varied and large population for the tourist and hunting industries it

needs to be managed at an ecosystem level which is much larger than the group ranches planned. This creates problems in that effective wildlife management will be external to ranch management, thus imposing a rigid structure of cattle and wildlife combinations on the rancher. The variation in returns to the landowner from the existing and potential forms of utilisation have been discussed in Chapter III and it was noted how these differed from the contribution of each activity to the national economy. Therefore, an optimum land use pattern at a regional level is not likely to manifest itself in the same form as the optimal land use pattern for the landowner. It should be stressed that there are legal loopholes which the landowner can use to exterminate the game on his land so there is an urgent need to develop and improve the channels by which revenue earned from wildlife utilisation activities is returned to the landowner. In addition, private returns must be raised to the level of public returns. If this does not happen the financial incentive for the landowner to retain game on his land is likely to be inadequate with the result that game could be eliminated in favour of cattle.

c. Implementation Problems

While land planners can determine an optimum land use pattern for a given area there may be considerable implementation problems. In the past the Maasai have shown reluctance to change from

their traditional way of life. For example, although loans have been offered under the World Bank Livestock Development Plan they were not eagerly accepted with the result that Phase I had to be extended because all the funds had not been taken up. Therefore, although cattle rearing may be an optimum form of land use in some areas of Kajiado District, the Maasai cannot be forced to change from their traditional way of life. In some cases implementation of an optimum land use pattern may have to be supported by appropriate legislation. As discussed above, in some areas it is in the national interest to preserve game but it is legally possible for landowners to exterminate game thus making new legislation necessary.

C A Comparison of the Potential Revenues from Game Cropping and Cattle Ranching in Kajiado District

The following analysis compares the potential revenue from game cropping and cattle ranching in Kajiado District. It was carried out earlier in my studies (in 1973) and serves to outline some of the problems facing land planners. For example, this work was done before an analysis of cropping costs had been made and as a result an important point emerged. The only figures for the cropping activity which were available when this analysis was carried out are simply averages based on the costs experienced by the Wildlife Management Project during experimental cropping operations and applied to all the technically croppable species. Therefore, a much larger croppable population is considered here compared to the economically defined population which was determined as a result of the analysis made in Appendix III[I]. The result is that average profit per animal is lower because those species which were

subsequently found as shown in Appendix III[I], not to be viable have been included. However, it can be seen from Appendix III[I] that these species, namely Impala, Thomson's and Grant's Gazelle, either yield a very small profit or make a small loss, therefore the total returns to the district are similar in this analysis to those discussed in Chapter III. Even so, the principles of this analysis remain valid and it is a case of adjusting the values used as more information becomes available. In addition, the assumptions and evaluation criteria set out emphasise the problems of lack of data and evaluating a subsistence economy.

This is really an exercise to outline one method of comparing two specified land use activities which is set out in a way which attempts to overcome the specific limitations of this situation. In this case the two activities discussed are game cropping and cattle ranching. The game cropping activity was considered because it is a new form of wildlife utilisation in Kajiado District, and therefore, needs to be studied. It is compared with cattle rearing because this is the main form of land use in that area.

In this case the extreme situation of replacing all the croppable game species by cattle or cropping the whole of the technically croppable game population is considered. In practice, this situation is unlikely to arise because while it is feasible that Kajiado landowners may remove all the game from their land, technical problems prevent cropping in the whole area of Kajiado District. For example, there are considerable areas where the vegetation, terrain and lack of access roads make cropping impossible. However, in a

situation where lack of data is a limiting factor it is often easier and more helpful to examine the extremes since this gives a useful insight into what might be anticipated in practice, and hence, indicates the direction which future research should take.

Methodology

The method of comparing these two forms of land use is exhibited by taking a particular area, in this case Kajiado District, making assumptions about the existing and future economic situation, there, and then, using these assumptions, computs the revenues from each activity. Throughout the paper the principle has been to use, where possible, a range of values for each variable instead of a single value. This is helpful in two ways. Firstly, it clearly shows how revenues change as the values of the different variables change in relation to each other. And, secondly, it enables revenue from the two forms of land use to be compared for situations which have different values for the variables involved.

More specifically this approach can be described as follows. Consideration is given to the two extreme situations of either cropping specific species in the game population or replacing those species of game by cattle for beef and subsistance milk production. On the basis of the assumptions set out in the following section, potential revenues have been calculated and tabulated for offtake of cattle and game at 5%, 10%, 15% and 20% of the total biomass. Potential revenues from cattle ranching have been calculated at 100%, 90%, 80%, 70% and 60% replacement rate of game by cattle, (this concept is defined in the following section).

For each situation the potential revenue has been calculated using current and projected prices. The conclusions are set out in two parts. The first part compares current and potential revenues from game cropping and beef production if the populations of croppable game species were replaced by cattle. The second part attempts to put a value on subsistence milk production and include it in the estimated value of the ranching activity.

Assumptions

Offtake

Several assumptions have been made with respect to offtake.

Firstly, offtake is calculated in terms of the percentage of biomass cropped and not the number of animals taken off. Use of the biomass concept simplifies the problem of comparing offtake rates of game and cattle.

Secondly, it is assumed that the same percentage of each species is cropped. In practice there would be a higher offtake of fast breeding animals and a lower offtake of slower breeding species. The assumption is made to simplify the analysis though it is possible to put in a different percentage for each species.

Thirdly, the average weight of animals cropped is assumed to be the same as the average weight of the herd for the purposes of calculating the number of skins produced. Thus, estimates of skin and hide revenue will tend to be on the high side.

Fourthly, although the killing out percentage will vary between species, an average killing out percentage of 50% is assumed for game. Although it usually is higher than this for individual game animals it is assumed that because some carcases will be condemned,

the overall production of edible meat will be 50% of the biomass cropped.

Replacement of Game by Cattle

The replacement rate is defined as the biomass (total animal weight which is supported on a given area of land) of cattle which can replace the existing biomass of game expressed as a percentage. Thus, for example, a 60% replacement rate indicates that on a given area of land each 1,000 kg of game biomass could only be replaced by 600 kg cattle biomass.

For simplicity's sake in this analysis it is assumed that all the croppable species are replaced by cattle and the average replacement rate is used. In practice the replacement rate will fall as cattle first replace species with which grazing competition is great until they are replacing species with which there is less competition for food. A graph of this situation is likely to take the following form (shown in Figure IV^{II} at the end of this chapter).

It has been assumed that cattle would only replace the technically potentially croppable game species: wildebeest, zebra, Grant's and Thomson's gazelle, impala, eland and kongoni. However, these species do not comprise 100% of the game biomass so that if all game was replaced by cattle the potential cattle biomass would be higher than indicated in this paper. On the other hand much of the biomass being replaced would be composed of species which have a low level of competition with cattle, e.g. giraffe. Also, the question of complementarity between cattle and game has been excluded from the following calculations because, firstly, there is a shortage of quantitative information on this

subject, and, secondly, the extreme situation of replacing all croppable species by cattle is being considered here so that the inclusion of complementarity factor is less pertinent.

Current Prices and Costs

The following assumptions are made about costs and prices:

Firstly, the average wholesale price for dressed game meat is Shs.3/50 per kg.

Secondly, the price for skins varies according to species. See Table IV[II].

Thirdly, cropping costs are based on information gained during experimental cropping operations by the Wildlife Management Project. Fixed costs which include depreciation, head office and management expenses and setting up costs are assumed to be Shs.676,375/- per annum. Variable costs include processing costs, maintenance of equipment, helicopter hire and those labour costs which vary with the level of production are assumed to be Shs.0.61725/- per kg meat produced. These figures are for use in the arithmetical calculation of cropping costs only and therefore appear more precise than was justified given the existing state of knowledge when this analysis was made. In determining the net revenue from cropping, revenue from the sale of skins as well as meat must be set against these costs.

Fourthly, the sale price of cattle is Shs.1/20 per kg on the hoof.

Fifthly, it is assumed that if cattle were to replace game they would incur dipping costs of Shs.10/- per head per annum and veterinary costs of Shs.20/- per head per annum.

Sixthly, although no labour costs as such are incurred on group ranches, labour costs are included in the cropping operation. Therefore, labour charges have been included at the rate payable on commercial farms - 150 cows per herder at Shs.20/- per month.

Seventhly, no capital costs are included in the cattle ranching activity because under traditional methods of management, capital investment is assumed to be nil. Dipping costs have been included above and obviously the construction of a dip represents a capital cost. In this case it is assumed that the cost of constructing the dip is sufficiently low and the capacity of such a dip sufficiently high that the capital cost incurred is included in the annual dipping costs of Shs.10/- per head.

Projected Prices and Costs

Livestock production in Kajiado District is being improved under the World Bank Livestock Development Plan. A series of assumptions about costs and prices after a period of five years has been made and the resulting potential revenues calculated.

Firstly, the price of game meat will rise by 60%. This rise is assumed because beef prices are projected to rise by 90%, under the World Bank Livestock Development Plan, increased exports of beef will reduce home supply and livestock development will result in reduced availability of low priced meat.

Secondly, the price of zebra skins will rise to Shs.450/- each and the average price of other game skins will rise from Shs.40/- to Shs.45/- each due to increased demand by the tourist industry.

Thirdly, it is assumed that overall cropping costs will rise by 50% due to the increasing demand for resources (e.g. skilled labour) associated with economic development.

Fourthly, the sale price of cattle on the hoof will rise to Shs.2/30 per kg as projected in the World Bank Livestock Development Plan.

Fifthly, it is assumed that dipping and veterinary costs will rise by 20% due to increased use, and labour costs by 50% because of the increasing demand for skilled labour.

Sixthly, no capital costs are included for the same reason as above. However, it must be remembered considerable investment in livestock development is being carried out under the World Bank Livestock Development Plan (e.g. breed improvement, water development) and some of the rise in beef prices will be due to better quality meat resulting from this development.

Conclusions

I Comparison of the Potential Revenues from Cropping and the Sale of Cattle

On the basis of the assumptions set out earlier the Tables at the end of this chapter build up the potential total and net revenues from the two alternative land use activities of cropping and cattle ranching. In this section only revenue from the sale of cattle is taken into account in determining the value of the ranching activity. The following section will be taken up with a justification for including the value of subsistence milk production and the effect of this on the value of production by the cattle sector.

Using the information in Table IV^{II}, Table IV^{III} goes on to build up the total revenue from cropping at specified offtake rates at current prices. Table IV^{IV} sets out the potential revenue from the sale of cattle at various replacement and offtake rates (again at current prices) if cattle were to replace game. Tables IV^{III} and IV^{IV} give rise to Table IV^{VI} which gives the net revenues from these alternative land uses. It is immediately apparent that cropping is the more profitable land use whatever offtake rate is taken in the 5-20% range. In fact, net revenue from cattle sales at a 20% offtake rate and 100% replacement rate is approximately 25% of the net revenue from cropping at the 5% level. Furthermore, it is interesting to note that the breakeven point (i.e. where total costs = total revenue) for cattle production is very high (approximately 18%) whereas cropping is profitable even at the 5% offtake level.

If we study the situation at projected prices a similar situation is found to exist. Table IV^{X} lays out the potential total revenue from cropping while Table IV^{XI} gives the potential total revenue from the sale of cattle. These two Tables are used to build up Table IV^{XII} which sets out the net revenues from these two activities. It can be readily appreciated that at any given level of offtake, cropping is the more profitable activity. In fact, cattle offtake has to reach a 17% level at a 100% offtake rate before it is earning net revenue comparable to net revenue from cropping at a 5% offtake level. The breakeven point for cattle production is lower than at current prices but still very much on the high side at approximately 12% offtake rate especially when cropping is profitable at even the 5% level.

It may be argued that these figures are biassed against cattle production for several reasons. Firstly, labour costs (Shs.1,156,283/- at current prices and Shs.1,734,422/-

at projected prices) have been included whereas in the typical Maasai situation the opportunity cost of labour approaches zero. Even adding back labour charges for any given level of offtake, net revenues from cropping exceed those from cattle, see Tables IV[VII] and IV[XIII]. At current prices cattle offtake would have to be 20% at 100% replacement rate to generate a net revenue equivalent to that earned by cropping at a 5% level. At projected prices the discrepancy is less marked but even so cattle offtake must be approximately 13.5% at 100% replacement rate to earn the same net revenue as cropping at a 5% offtake level. Secondly, if cattle were to replace all game it would be possible to put on a greater biomass than indicated in this paper because only croppable species have been included (e.g. buffalo). In practice it is virtually impossible to estimate the extent of this increased biomass because of lack of data on animal numbers and competition between cattle and these species. Thirdly, it must be remembered that it is reasonable to expect lower offtake rates for game compared with cattle. In the first place there is less opportunity for close control and manipulation of population structure, and in the second place, some game animals are being utilised in other ways, that is for hunting and live capture. However, as discussed in Chapter III, the return on a per animal basis for all species except wildebeest, is greater from hunting and capture than it is from cropping.

Therefore, given the assumptions set out earlier in this paper cropping is shown to be the more profitable activity when it is compared with sale of cattle. However, it must be remembered that in practice, for the reasons set out previously, it will be impossible to crop the whole of the technically croppable population. In order to achieve

a given offtake level it will probably be necessary to take double the percentage rate offtake from that half of the population which habitates croppable areas.

However, there are some very sound reasons for including the value of subsistance milk production in the output of the ranching activity.

II Comparison of Potential Revenue from Cropping and Cattle Ranching (including the value of subsistance milk production)

Justification for including the Value of Subsistance Milk Production

On the question of evaluating traditional ranching activities, two schools of thought exist. On the one hand the value of milk produced for human consumption is ignored because it does not enter the cash economy. On the other hand milk forms an important and essential part of the Maasai diet which they are currently unable to satisfactorily replace due to low incomes and poor distribution of food. Also, the Agricultural Finance Corperation, which is responsible for disbursing livestock improvement funds under the World Bank Livestock Development Plan, is concerned with improving milk production per cow, the intention being that in the light of low infrastructural development in Kajiado District, group ranches should continue to produce milk for their own consumption. It can be argued that to count milk production and beef production results in overevaluation of the ranching activity but this is not necessarily the case. Milk production can be thought of in two parts: that which is used for human consumption and that which is utilised by the calf. In the case of the former it is valued at a price which will be discussed later. The latter is given no value because it is part of the process of beef production and hence included in the value of the finished beef animal. As some of the milk is being utilised by people,

fewer calves can be reared on the remaining milk, therefore in a combined milk and calf production activity the estimated potential revenue from beef production will be lower than in a beef only production activity. Therefore, if we adopt this method of estimating milk production in two parts and taking an appropriately lower level of beef production, (i.e. the level of beef production which the Maasai are currently achieving and expect to achieve in the future because they are operating a combined milk and beef production activity) there is no element of double counting.

Having studied the argument in favour of including an element for the value of milk consumed, how should this milk be priced? Several criteria could be used. For example, the retail price of milk (Shs.1/60 per litre) may be taken since this would be the price the Maasai would have to pay for milk if they were not producing it from their own cattle. In other words, it is the cost of maintaining their existing diet. One could take the wholesale price (88 cents per litre) which is the value of the milk if they were to sell it, though this price is fixed by the Government, and therefore, is not necessarily at the level which would exist in a free market. Alternatively, either the production or opportunity costs could be used.

For the purposes of this paper the wholesale price of 88 cents per litre less 18 cents for transport costs is taken. Use of the retail price may over-estimate the value as the Maasai are likely to buy cheaper substitute foods. Apart from the problems of calculating production and opportunity costs they are likely to be an under-estimate because in an area such as Kajiado there are few alternative land uses and also a traditional method of cattle management is operated.

Assumptions

Firstly, it is assumed that in the current situation 33% of the herd is composed of milking females giving on average a yield of 1.22 litres per day. (This estimate was made by David Western for Amboseli). Hence, the value of the daily yield per cow is rounded to Shs.0.875. Any livestock development is aimed at maintaining total milk production (i.e. the number of females is reduced but the calving interval and yield per lactation is improved). Therefore, the total level of milk production has been calculated using the above figures since it is anticipated that this figure will at least be maintained.

Secondly, in order to calculate the number of milking females it was assumed that the weight of a breeding female was equal to the average weight of the herd which is currently taken to be 180 kg.

Thirdly, if cattle replaced the croppable game species then it is assumed that given a 100% replacement rate, the total cattle population of Kajiado District could increase by 120,446 head of cattle. For the purpose of this analysis it is assumed that breeding females and hence milk production would increase by a proportionate amount. The value of this increased milk production is included in the calculations because it is assumed that it will be utilised to feed the growing population of Kajiado District and/or to raise current consumption levels replacing other inferior types of food.

Fourthly, it is assumed that the farm gate price of milk (i.e. wholesale price) will increase by 20% due to increased demand resulting from an increase in population and the planned overall rise in the standard of living leading to a greater consumption per capita of dairy products.

Deductions

While it has just been shown that cropping is more profitable than cattle ranching, if the value of subsistance milk production is included in the calculations the situation is completely reversed. Table IV[V] sets out the total revenue from milk and meat production at current prices and Table IV[VIII] goes on to build up the net revenues from cropping and cattle production. Clearly these figures indicate that cattle rearing is a more viable proposition since even at a 10% offtake rate, net revenue from cropping is less than net revenue from cattle ranching at a 50% replacement rate and a 5% offtake level. The situation becomes less exagerrated as the offtake rate rises but even at a 20% offtake rate the replacement rate must fall to 70% before cropping becomes more profitable. However, the replacement rate would depend on the ecology of the area under discussion.

The same picture is apparent when consideration is given to potential revenues at projected prices. Table IV[X] builds up the total revenue from cropping and Table IV[XI] sets out revenue from sale of cattle and the value of milk production. Table IV[XIV] uses the data from these two tables to show potential net revenues from cropping and cattle ranching for meat production and subsistance milk. It can be seen that the same offtake rate must be at the 10% level before it produces a net revenue equal to cattle production with an offtake rate of 5% and a replacement rate of 60%. At higher offtake levels this difference is less accentuated but even so it is still significant. For example, at the 20% offtake level, replacement rate has to fall to 70% before the net revenue produced is less than the net revenue from cropping. The arguments, set out in the first part of this conclusion, which indicate that the revenue from cattle production may

be underestimated still apply. These arguments include, firstly, the question of whether or not labour charges should be included in the ranching activity (see Tables IV[IX] and IV[XV]). Secondly, whether cattle would, in practice, replace all species of game and not just the croppable ones and thirdly, cattle offtake rates are expected to be above potential game offtake rates. Thus, these three aspects suggest that revenue from cattle production would probably be in excess of that indicated making the advantage of cattle rearing even greater than the tables show.

Conclusion

In conclusion, three points should be emphasised.

Firstly, assuming that labour would not be paid in cash in the cattle rearing activity, then the net cash flow situation would be as indicated in Tables IV[VII] (current prices) and IV[XIII] (projected prices). At low levels of offtake, below approximately 1½% at current prices and below approximately 9% at projected prices the cash flow is negative. Therefore, although the tables show that if the value of subsistance milk production is included in the calculations then cattle rearing is of greater value than cropping, the rancher could not operate a ranching activity at low levels of offtake. This is, obviously, of great significance in economic planning.

Secondly, it has been shown that given the assumptions made in this analysis, cropping is more profitable than cattle ranching but once the value of subsistance milk production is included the situation is completely reversed. This is a very nice example of the answer one gets depending on the assumptions made in the first place.

Thirdly, cropping constitutes only one form of wildlife utilisation which does not necessarily exclude other forms of utilisation and which are currently more profitable. In other words, revenue from cropping forms only one part of

the total revenue which may be earned from wildlife if a multiple utilisation programme including live capture, hunting and tourism based on wildlife viewing, as well as cropping, is put into operation. The revenues from these other forms of utilisation have been discussed in Chapter III.

Figure IV[I]. The Optimum Combination of Cattle and Game on a Given Parcel of Rangeland.

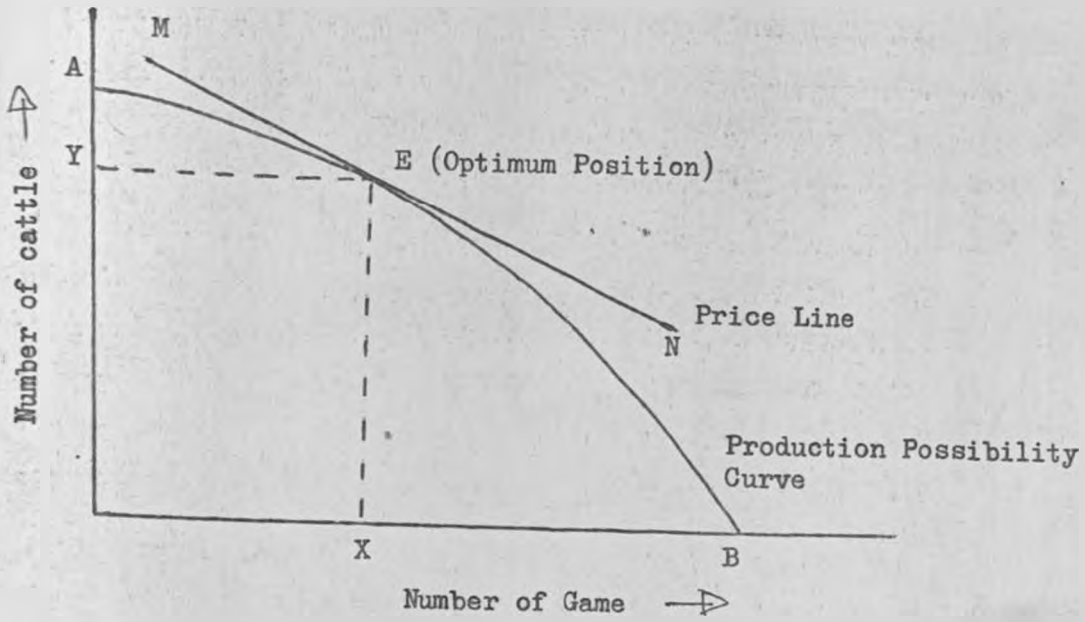
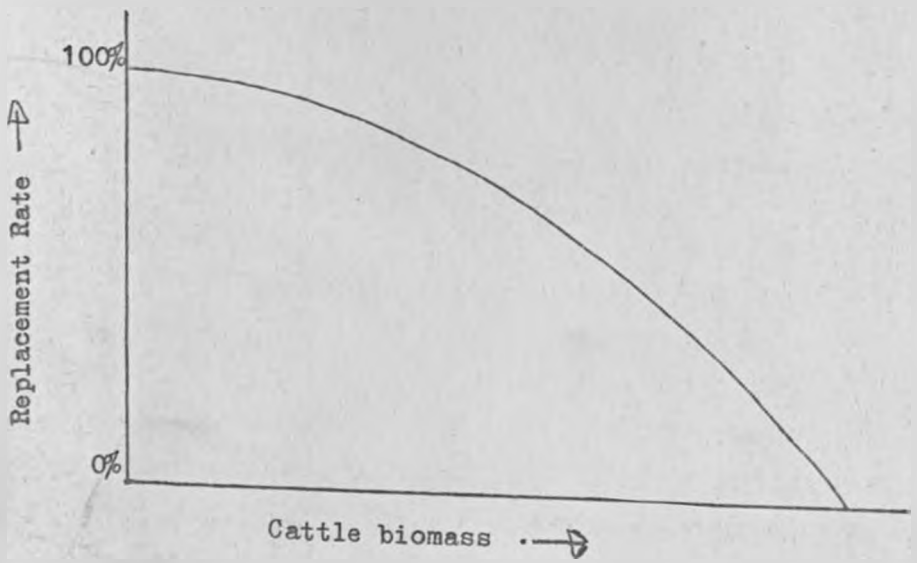


Figure IV[II]. The Relationship between the Replacement Rate and the Cattle Biomass.



N.B. All Tables have been computed to two decimal places and then rounded but it should be remembered that they are based on data which is not necessarily reliable enough to merit such a degree of accuracy. Any discrepancies are due to rounding.

TABLE IV[I]. THE BIOMASS OF CROPPABLE SPECIES IN KAJIADO DISTRICT

Species	No.*	Average Weight * (kg)	Total Biomass (kg)
Wildebeest	59,392	190	11,284,480
Grant's Gazelle	25,207	40	1,008,280
Zebra	27,770	200	5,554,000
Kongoni	16,175	120	1,941,000
Impala	14,224	40	568,960
Thomson's Gazelle	3,716	17	63,172
Eland	3,151	400	1,260,400
TOTAL	149,635		21,680,292

* Data supplied by the UNDP/FAO Management Projects.

TABLE IV[II]. THE VALUE OF GAME SKINS

Species	Value of Skin (Shs.)
Eland	25/-
Thomson's Gazelle	25/-
Kongoni	25/-
Impala	25/-
Grant's Gazelle	35/-
Wildebeest	50/-
Zebra	300/-

TABLE IV[III]. TOTAL REVENUE FROM CROPPING AT CURRENT PRICES

Offtake Rate (% Total Biomass)	Biomass Croppable (kg)	Meat Production (kg) 50% K.O.%	No. of Skins Zebra	No. of Skins Others	Value of Meat Shs.3/50/kg	Value of Skins (Shs.) Zebra	Value of Skins (Shs.) Others	Value of Skins (Shs.) Combined	Total Revenue (Shs)
5%	1,084,015	542,007	1,388	6,093	1,897,026	416,400	239,168	655,568	2,552,593
10%	2,168,029	1,084,015	2,776	12,186	3,794,051	832,800	478,335	1,311,135	5,105,186
15%	3,252,044	1,626,022	4,165	18,280	5,691,077	1,249,200	717,503	1,966,703	7,657,779
20%	4,336,058	2,168,029	5,554	24,373	7,588,102	1,665,600	956,670	2,622,270	10,210,372

TABLE IV[IV]. TOTAL REVENUE FROM SALE OF CATTLE AT CURRENT PRICES

Offtake Rate (% Total Biomass)	Biomass Croppable (kg) at 100% replacement rate	Total Revenue from sale of beef cattle at Shs.1/20 kg Replacement Rate 100%	90%	80%	70%	60%
5%	1,084,015	1,300,818	1,170,736	1,040,654	910,572	780,491
10%	2,168,029	2,601,635	2,341,472	2,081,308	1,821,145	1,560,981
15%	3,252,044	3,902,453	3,512,207	3,121,962	2,731,717	2,341,472
20%	4,336,058	5,203,270	4,682,943	4,162,616	3,642,289	3,121,962

TABLE IV[V]. TOTAL REVENUE FROM CATTLE PRODUCTION (SUBSISTANCE MILK AND CATTLE SALES) AT CURRENT PRICES

Offtake Rate (% Total Biomass)	Total Revenue (Shs.) from milk and sale of beef cattle 100%	90%	80%	70%	60%	Value of Milk Production (Shs.)
5%	12,398,141	11,158,327	9,918,513	8,678,698	7,438,884	11,097,323
10%	13,698,958	12,329,062	10,959,167	9,589,271	8,219,375	11,097,323
15%	14,999,776	13,499,798	11,999,821	10,499,843	8,999,865	11,097,323
20%	16,300,593	14,670,534	13,040,475	11,410,415	9,780,356	11,097,323

TABLE IV[VI]. NET REVENUES FROM CROPPING AND SALE OF CATTLE AT CURRENT PRICES

Offtake Rate (% Total Biomass)	Net Revenue from Cropping (Shs.)	Net Revenue from sale of Beef cattle (Shs.) Replacement Rate 100%	90%	80%	70%	60%
5%	1,541,663	- 3,468,845	- 3,121,961	- 2,775,076	- 2,428,191	- 2,081,307
10%	3,759,701	- 2,168,028	- 1,951,225	- 1,734,422	- 1,517,619	- 1,300,817
15%	5,997,738	- 867,210	- 780,489	- 693,768	- 607,047	- 520,326
20%	8,193,776	433,608	390,247	346,886	303,585	260,165

TABLE IV^{VII}. NET REVENUE (EXCLUDING LABOUR COSTS) FROM SALE OF CATTLE AT CURRENT PRICES

Offtake Rate (% Total Biomass)	Replacement Rate 100% (Shs.)	90% (Shs)	80% (Shs)	70% (Shs)	60% (Shs)
5%	- 2,312,563	- 2,081,307	- 1,850,050	- 1,618,794	- 1,387,538
10%	- 1,011,745	- 910,570	- 809,396	- 708,221	- 607,047
15%	289,073	260,165	231,258	202,351	173,444
20%	1,589,890	1,430,901	1,271,912	1,112,923	953,934

TABLE IV^{VIII}. NET REVENUES FROM CROPPING AND CATTLE PRODUCTION (SUBSISTANCE MILK AND CATTLE SALES) AT CURRENT PRICES

Offtake Rate (% Total Biomass)	Net Revenue from Cropping (Shs.)	Net Revenue from milk production and sale of beef cattle (Shs.) Replacement Rate 100%	90%	80%	70%	60%
5%	1,541,663	7,628,479	6,865,631	6,102,783	5,339,935	4,577,087
10%	3,759,701	8,929,297	8,036,367	7,143,437	6,250,508	5,357,578
15%	5,977,738	10,230,114	9,207,103	8,184,091	7,161,080	6,138,069
20%	8,195,776	11,530,931	10,377,839	9,224,745	8,071,752	6,918,559

TABLE IV^{EX}. NET REVENUE (EXCLUDING LABOUR COSTS) FROM CATTLE PRODUCTION (SUBSISTANCE MILK AND CATTLE SALES) AT CURRENT PRICES

Offtake Rate (% Total Biomass)	Replacement Rate 100% (Shs)	90% (Shs)	80% (Shs)	70% (Shs)	60% (Shs)
5%	8,784,762	7,906,286	7,027,809	6,149,333	5,270,857
10%	10,085,579	9,077,021	8,068,463	7,059,905	6,051,348
15%	11,386,397	10,247,757	9,109,117	7,970,478	6,831,838
20%	12,687,214	11,418,492	10,149,771	8,881,650	7,612,329

TABLE IV^{X}. TOTAL REVENUE FROM CROPPING AT PROJECTED PRICES

Offtake Rate (% Total Biomass)	Value of Meat Production (Shs5/60 per kg)	Value of Skins (Shs.) Zebra	Others	Combined	Total Revenue
5%	3,035,241	624,600	274,196	898,796	3,934,037
10%	6,070,482	1,249,200	548,393	1,797,593	7,868,074
15%	9,105,723	1,873,800	822,589	2,696,389	11,802,111
20%	12,140,964	2,498,400	1,096,785	3,595,185	15,736,149

TABLE IV[XI]. TOTAL REVENUE FROM CATTLE PRODUCTION (SUBSISTANCE MILK AND CATTLE SALES) AT PROJECTED PRICES

Offtake Rate (% Total Biomass)	Total Revenue from sale of beef cattle (Shs.) Replacement Rate 100%	90%	80%	70%	60%	Total Value of Milk Production (Shs)
5%	2,493,234	2,243,910	1,994,587	1,745,264	1,495,940	13,316,788
10%	4,986,467	4,487,820	3,989,174	3,490,527	2,991,880	13,316,788
15%	7,479,701	6,731,731	5,983,761	5,235,791	4,487,820	13,316,788
20%	9,972,934	8,975,641	7,978,347	6,981,054	5,983,761	13,316,788

TABLE IV[XII]. NET REVENUES FROM CROPPING AND SALE OF CATTLE AT PROJECTED PRICES

Offtake Rate (% Total Biomass)	Net Revenue from Cropping (Shs)	Net Revenue from sale of Beef Cattle (Shs) Replacement Rate 100%	90%	80%	70%	60%
5%	2,417,642	- 3,577,245	- 3,399,520	- 2,861,796	- 2,504,071	- 2,146,347
10%	5,849,846	- 1,084,011	- 1,155,610	- 947,209	- 758,808	- 650,407
15%	9,282,050	1,409,222	1,268,300	1,127,378	986,456	845,533
20%	12,714,255	3,902,456	3,512,210	3,121,965	2,731,719	2,341,474

TABLE IV[XIII]. NET REVENUE (EXCLUDING LABOUR COSTS) FROM SALE OF CATTLE AT PROJECTED PRICES

Offtake Rate (% Total Biomass)	Replacement Rate 100% (Shs)	90% (Shs)	80% (Shs)	70% (Shs)	60% (Shs)
5%	- 1,842,822	- 1,658,540	- 1,474,258	- 1,289,976	- 1,105,693
10%	650,411	585,370	520,329	455,288	390,247
15%	3,143,645	2,829,280	2,514,916	2,200,551	1,886,187
20%	5,636,878	5,073,190	4,509,503	3,945,815	3,382,127

TABLE IV[XIV]. NET REVENUES FROM CROPPING AND CATTLE PRODUCTION (SUBSISTANCE MILK AND CATTLE SALES) AT PROJECTED PRICES

Offtake Rate (% Total Biomass)	Net Revenue from Cropping (Shs)	Net Revenue from Milk Production and sale of Beef Cattle (Shs) Replacement Rate 100%	90%	80%	70%	60%
5%	2,417,642	9,739,544	8,765,589	7,791,635	6,817,681	5,834,726
10%	5,849,846	12,232,777	11,009,499	9,786,222	8,562,944	7,339,666
15%	9,282,050	14,726,011	13,253,410	11,780,809	10,308,208	8,835,606
20%	12,714,255	17,219,244	15,497,310	13,775,395	12,053,471	10,331,547

TABLE IV[XV]. NET REVENUE (EXCLUDING LABOUR COSTS) FROM CATTLE PRODUCTION (SUBSISTANCE MILK AND CATTLE SALES) AT PROJECTED PRICES

Offtake Rate (% Total Biomass)	Replacement Rate 100% (Shs)	90% (Shs)	80% (Shs)	70% (Shs)	60% (Shs)
5%	11,473,966	10,326,569	9,179,173	8,031,776	6,884,320
10%	13,967,200	12,570,480	11,173,760	9,777,040	8,380,320
15%	16,460,433	14,814,390	13,168,347	11,522,303	9,876,260
20%	18,953,667	17,058,300	15,162,933	13,267,567	11,372,200

CHAPTER V

A SUMMARY OF THE PROBLEMS OF DETERMINING OPTIMUM WILDLIFE UTILIZATION PATTERNS

The intention of this chapter is to bring together briefly the problems which have been discussed in this thesis, and hence, outline the most urgent areas of research. In conclusion the future status of wildlife in Kajiado District is discussed.

A Summary of the problems of Including Wildlife Utilisation Activities in Land Planning.

The desire for economic development in Kenya leads to the need for careful land planning so that the available resources can be utilised in the most efficient manner. On a conceptual basis the land planner is faced by the question "Who is supposed to benefit from land planning?" Economic development of a particular area will benefit the country as a whole but it may not necessarily benefit the people of that area in the way they desire. For example, land adjudication and the setting up of large commercial cattle ranches in Kajiado District will benefit the Kenyan economy by producing large amounts of export quality beef. However, this involves changing the Maasai from their subsistance economy and nomadic way of life to a cash oriented economy and a sedentary way of life. The Maasai themselves have demonstrated that such a change may not be in their interests. In spite of the changes which have been occurring around them they are reluctant to take up the loans offered by the Agricultural Finance Corporation which would assist them to set up large commercial cattle ranches. This aspect has been raised in Chapter IV.

The two major forms of utilisation requiring research are the viewing activity and the hunting industry. In spite of the fact that these two forms of utilisation are much more important economically than cropping or capture, relatively far less is known about them. As a result of the experimental cropping carried out by the Wildlife

Management Project, the data from which is set out in the Project Working Document on Cropping, there is probably enough information to make an adequate analysis of the potential revenue from cropping. Likewise, given access to raw data at the Game Department of the Ministry of Wildlife and Tourism there is adequate knowledge of the capture activity.

Within the tourist sector the most limiting facet is the lack of knowledge of the demand for viewing. In other words the general relationship between the number of tourists and the cost of viewing is unknown. In practice, the demand for each park will not be the same because they offer different attractions. For example, consider Amboseli and Nairobi National Parks. There is an excellent view of Mount Kilimanjaro from Amboseli and in addition certain species, such as elephant, oryx and gerenuk are found there, but not in Nairobi National Park. Therefore, a tourist would be willing to pay more to visit Amboseli but how much is not known. If this information was known it would be possible to set the combined travelling, accommodation and entrance costs of visiting a particular park at a level such that returns from viewing are maximized without the capacity of the park being exceeded. Secondly, it is necessary to ensure that the viewing revenue is distributed between the involved parties (Ministry of Wildlife and Tourism, tour operators, lodge owners and landowners around the Parks) in such a way that their private returns reflect the national returns from this activity. As discussed in Chapter III this is not the case at the moment and the necessity that this should be so is fully considered there. To this end a system of income redistribution needs to be introduced.

There are two pressing areas of research within the hunting sector. Firstly, the demand for hunting by residents and non-residents needs to be determined. More precisely it is necessary to determine the relationship between the total fees payable for shooting an animal of a given species and the number which would be shot at that price. Secondly, the potential offtake of a given population must be determined. This is a significant point because too high offtake will result in the population being depleted to the detriment of future returns and a too low offtake means the potential returns are not being fully reaped. Put another way, it is necessary to know the minimum population necessary to yield the offtake which will maximise returns from hunting. Offtake rate formulae have been developed in Chapter III. These formulae have been deliberately constructed so that they can be applied to all huntable as well as croppable species. However, as pointed out there, we do not currently have adequate information to utilise these formulae and therefore the collection of the data outlined there is a pressing area for research by zoologists.

It can be argued that the system operating currently is adequate. In practice the actual offtake is determined by the hunters' demand for a particular species at the total fees payable for shooting that type of animal. The offtake is only limited if the population appears to be declining. While this might have been adequate in the past, we are now facing a situation of increasing pressure from other forms of land use. In the case of Kajiado District, the most significant pressure is from the World Bank Livestock Development Plan and it is not simply a need to obtain some return from Wildlife Utilisation. The

maximum return from hunting can be determined on the basis of the nature of demand for hunting and the potential off-take from a given wildlife population. Unless the maximum returns are obtained then the level of utilisation will be lower than it should be to the detriment of both the individual landowner and the national economy as a whole.

If the areas of research outlined above for both the hunting and tourist industries were fulfilled then it would be possible to carry out accurate land planning. Since this information is unknown at present projections for these two activities have to be based on assumptions which is not satisfactory as the answers obtained will only be as good as the accuracy of the assumptions on which they are based.

In addition, there is a need to select investment techniques so that different enterprises can be compared on the same basis. Since wildlife is a renewable natural resource the appraisal techniques often used in the livestock sector may give non-sensical results when applied to wildlife utilisation activities, thus preventing a comparison of the returns from these enterprises. For example, livestock men may evaluate their enterprise by expressing net revenue as a percentage of the capital investment in the livestock itself. However, as far as the landowners of Kajiado District are concerned, it required no capital cost to put or keep wildlife on their land as it is already there. This is particularly true for those ranches around Amboseli and Nairobi National Parks as they are the wet season dispersal areas for these parks. Therefore, if net revenue is expressed as a percentage of the capital investment in livestock, mathematically the answer is infinity, which is meaning-

less for the purposes of practical land planning. In this situation it is necessary to carefully define the various types of cost in each activity and ensure that the same costs and returns are being compared. If this is not done and unlike costs and returns are compared the results obtained can be highly misleading.

By the same token the subsistance economy of the Maasai needs to be examined and evaluated in such a way that it can be compared with the other forms of cash orientated activities which might replace it. The problems of dealing with a subsistance economy have been outlined in Chapter IV and this is definitely an area urgently requiring extensive research.

Finally, an outstandingly important area of research can be broadly defined as the relationship between livestock and game. This is principally concerned with the trade-off between cattle and game in physical terms. In other words, economists need to know the biomass of cattle and/or game which a given area can support so that they can calculate the optimum economic mix of species.

II The Future Status of Wildlife in Kajiado District

On the one hand the UNDP/FAO Wildlife Management is researching various aspects of wildlife utilisation and management and organising Wildlife Utilisation in Kajiado District. On the other hand, the World Bank Livestock Development Plan is being implemented there and aims to increase the quality and quantity of beef production. It is the author's opinion that the latter project will have a highly detrimental effect on the future status of game. There are two principal reasons for this.

Firstly, under this plan watering points are being constructed in areas which were previously inaccessible to cattle because of their distance from water. However, the Agricultural Finance Corporation which is responsible for providing credit and guidance for the schemes has no legal powers to control cattle numbers. The result will be that instead of more grazing being available for the same number of cows there will simply be an increase in cattle numbers, accentuating the overstocking problem which already exists. The increase in cattle stocking will lead to greater habitat destruction and a further reduction in carrying capacity. This will influence the wildlife population in two ways. Firstly, by constructing watering points in arid areas the game in that area will be pushed out by the cattle that move in. The extent to which the game population is reduced will depend on how favourable that area is for cattle. Secondly, the problem of habitat destruction and reduction of carrying capacity as a result of overstocking also influences the game population since destruction of habitat reduces the carrying capacity for game as well as cattle. It may be argued that a given area should be stocked to the carrying capacity under good conditions and then when the carrying capacity falls because of drought, overstocking and habitat destruction are avoided by taking off the appropriate number of cattle. However, the principal abbatoir for Kajiado District is at Athi River and it has inadequate facilities to take off a large enough number of cattle in a short enough time to alleviate grazing shortage and habitat destruction problems. Obviously it is not an economically viable proposition to construct an abbatoir large enough to cope with a large and rapid offtake since such an offtake would only be necessary during severe droughts and for the majority of time it would be lying idle. In any

case even if it were possible to achieve an adequate offtake these cattle would have to be replaced from somewhere in order to build up to the full carrying capacity under optimum conditions. However, the major cattle rearing areas of Kenya are semi-arid and therefore liable to frequent drought. Drought is often widespread and thus a vast amount of replacement cattle would be required under this type of management regime. In order to prevent this increase in cattle, and the detrimental effect of this on game populations, it is suggested that water facilities should not be increased until cattle numbers can be controlled. This control can be achieved by educating the ranchers and/or by legal restrictions.

Secondly, under this livestock development plan, land is being adjudicated to the Maasai in Kajiado District. As the game laws stand, there are legal loopholes which enable a landowner to eradicate the game on his land. There are a variety of reasons why a landowner would not want wildlife on his property and these aspects have been enumerated in Chapter I (Section III A). The result is that it would be reasonable to expect that the Maasai landowner would be no different from any other landowner and take advantage of the existing legal loopholes. Unfortunately, it is the large species and predators which the landowner would seek to destroy first since not only do they appear to do most damage but they are easier to eradicate on account of their size. In terms of viewing attraction, it is these species such as lion, cheetah, leopard, elephant and the large antelopes which provide the viewing attraction and both the national parks in Kajiado District are dependant on the surrounding ranches as feeder areas. At this point the case of the wildebeest should be noted.

As discussed earlier, the Maasai do not like them amongst their cattle and as a sizeable plains animal it would be easily exterminated. However, Kajiado District is the only area of Kenya where the wildebeest ecosystem is contained entirely in this country. The only other area where they are found is in the Masai Mara area and the population there migrates backwards and forwards from the Serengeti in Tanzania.

The remedy to this situation is to ensure that the landowner has adequate economic incentives to preserve game. It is essential that all species of game are preserved as a large range of species is necessary to provide a good viewing and hunting attraction. The magnitude and flows of revenue in the wildlife sector were discussed in Chapter III and it was apparent that income redistribution is vital if the landowners were to receive sufficient monetary incentive. In fact it was pointed out that so far the occupants of Kajiado District have directly benefited from tourism nor hunting there. It is essential that these economic incentives reflect the natural value of the various wildlife utilisation activities to the landowner. The cost and return structure facing the landowner should be such that the ratio of cattle to game he keeps on his land reflects the relative value of each activity at national level. This is simply said, but, in fact, considerable research is required to determine the value of cattle rearing relative to the various wildlife utilisation activities and develop ways in which this can be reflected to the landowner in terms of his potential returns from each enterprise.

The subject is complicated by the fact that the Maasai subsistance economy is in the process of moving to a cash orientated one and this involves a change in values. By definition a subsistance economy is entirely divorced from any cash flows but in the Maasai economy each family will have a small amount of cash from the sale of cattle which may be used to pay school fees and buy some basic foodstuffs such as tea and sugar. Mr. Vincent Sang of the Agricultural Finance Corporation estimates that an average Maasai family would own fifty cattle and sell five each year realising a cash income of approximately sixteen hundred shillings. A poor family would own fifteen cattle and only sell one per year for approximately three hundred and twenty five shillings. In the light of this information it can be seen that, at present, the return to landowners from wildlife need not necessarily be very large to provide an adequate incentive to maintain game on their land. For poor Maasai families an annual income of only one hundred shillings from wildlife would represent 30% of their annual income, which might provide a very persuasive incentive. However, as commercial cattle ranches are established and the Maasai economy becomes fully cash oriented, the above returns would not be adequate and would have to be raised to fulfill the criteria set out above.

These economic measures to encourage landowners to keep wildlife should be backed up by legal controls which are adequately enforced. A non-profit motivated organisation should establish and enforce offtake quotas. This is necessary since for many species the ecosystem in which they move around is much larger than the average ranch so that the offtake of each species will need to be

divided between the ranches involved. On the question of offtake quotas particular mention should be made of the poaching problem. When establishing legal offtake quotas the level of offtake by poachers should be taken into account since, at best, it would seem that the appropriate authorities will only be able to bring it under reasonable control.

III Conclusion

In this final chapter, the most pressing areas for further research have been outlined. It is necessary that this work is carried out and the results quickly enforced by economic and legal measures. Failure to do this may well result in the pressures from other sectors, particularly the World Bank Livestock Development Plan, causing a radical reduction in the wildlife population of Kajiado District. This process will be accelerated because the current legal restrictions and economic incentives with regard to wildlife are weak and inadequate.

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